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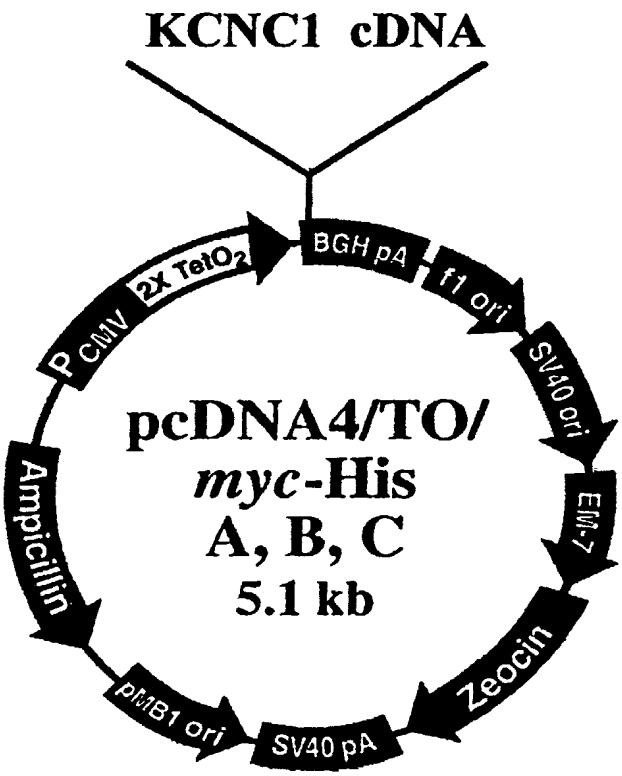

(57) Abstract: Methods for identifying an ion channel modulator, a target membrane receptor modulator molecule, and other modulatory molecules are disclosed, as well as cells and vectors for use in those methods. A polynucleotide encoding target is provided in a cell under control of an inducible promoter, and candidate modulatory molecules are contacted with the cell after induction of the promoter to ascertain whether a change in a measurable physiological parameter occurs as a result of the candidate modulatory molecule.

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IDENTIFICATION OF MODULATORY MOLECULES USING INDUCIBLE PROMOTERS

Technical Field

The present invention relates generally to the technical fields of molecular biology and drug discovery. More specifically, the invention relates to the method of identifying a drug target modulator using an inducible vector.

Background of the Invention

Advances in molecular biology have increased the efficiency of gene isolation and sequencing. Additionally, the availability of known sequences and sequence alignment programs allow comparisons to be made leading to the identification of motifs that are conserved between members of the same family or similar classes. This allows genes to be assigned to particular target families, such as G-protein coupled receptors or ion channels. However, in the case of receptors, sequence information of the target does not provide the identity of the receptor's native ligand or that ligand's biological function. For example, single transmembrane membrane receptors contain a cysteine rich domain, followed by an alpha helix motif, followed by a tyrosine kinase domain. This may suggest that the sequence is a receptor, whereby the cysteine rich domain is involved in ligand binding, the alpha helix traverses the membrane, and the tyrosine kinase domain is involved in cellular signaling. Unfortunately, sequencing an unknown receptor's ligand binding domain does not provide sufficient information that would easily lead to the identity of the ligand. Similar problems occur when searching for the function of ion channels, enzymes, transporters, transcription factors, nuclear receptors, chaperone proteins and other regulatory molecules within the cell. Consequently, experiments must be designed and performed to identify the sequence's function and modulatory compounds.

Controlled expression of the target sequence is necessary to identify modulatory compounds because constitutive expression often leads to over expression of the protein. This is frequently toxic to the cell or can cause down-regulation of the target by stimulation of internalization and degradation processes. However gene expression is difficult to control in terms of both the level and time course of target expression. Current expression vectors are usually designed to maximize expression levels, and therefore yield cells that continuously express the target. Alternatively, techniques such as transient transfection reduce the target's duration of expression, but these techniques often lead to heterogeneous expression among replicate samples, are labor-intensive, and may damage the cells or alter their function due to the need to penetrate the membrane to deliver exogenous genes, making data difficult to collect and analyze.

The activity of a compound against a target of interest is determined by a variety of techniques. Some examples include randomly screening the compound against cells transfected with the target, testing compounds in cells where the target has been mutated to express the protein

in its active state, and binding studies between a compound and an isolated form of the target. However each has problems associated with the technique.

Random screening of transfected cells requires a number of assumptions that often may not be tested. It requires the target protein be properly expressed, correctly localized within the cell, functionally coupled to a signaling mechanism, and expressed stably throughout the duration of the testing process. However, when the function of the target is unknown, these requirements can not be tested.

When the target is a membrane protein such as a G-protein coupled receptor ("GPCR"), it may be mutated such that the protein is expressed in its activated form. Since ligand binding of the mutated protein frequently causes a drop in activity, an assay that detects a drop in activation suggests the compound binds the target. However, since this technique identifies compounds which bind to a mutated protein, the compounds may not possess the same affinity or avidity for a native protein. In addition, this technique is not available when information regarding the design of an activated receptor is unavailable, such as the active form of ion channels.

Another frequently used technique to identify modulators is to perform competitive binding assays. However, competitive binding assays require a native ligand to assay the compound, and as previously discussed they are frequently unknown.

Lastly, assays that directly measure binding interactions using purified proteins allow the measurement of interactions between compounds and targets. Examples of direct binding assays are surface plasmon resonance spectroscopy, thermal denaturation profiling, and multipole coupling spectroscopy. However, these techniques only detect binding and are not functional assays. They do not distinguish between agonists, antagonists, or non-functional interactions. Moreover, when the targets are membrane proteins in their native form, purification is not always possible. When a purified form is unavailable, interaction among other molecules in the preparation may lead to false positives or false negatives in the assay.

Therefore there is a need for methods to assay the effects of compounds on the function of biological targets. Specifically, there is a need for an assay that allows control of the expression of the target sequence, identifies target expressing cells, expresses the target in its native form, can distinguish between agonists, antagonists, and nonfunctional interactions and may be performed within the cellular environment.

Brief Description of the Figures

Figure 1 is an illustration of the inducible expression vector comprising a tetracycline inducible promoter, a pcDNA4/TO vector construct and a murine KCNC1 potassium ion channel gene.

Figure 2 is a photograph of a 1.5% agarose gel demonstrating KCNC1 mRNA production of clones 7, 13 and 22 under non-induced ("(-)Tet") and induced ("(+)Tet") conditions.

Figure 3 is a photograph of immuno-staining of KCNC1 produced by clone 22 under non-induced ("(-)Tet") and induced ("(+)Tet") conditions.

Figure 4 is a graph demonstrating hyperpolarization of an induced population of cells compared to a non-induced population of cells and their responses to 50 mM, 100 mM and 150 mM KCl.

Figure 5 is a graph demonstrating that cells induced to overexpress KCNC1 when pre-incubated with 4-aminopyridine, show characteristics more similar to uninduced cells.

Figure 6 is a graph demonstrating that cells induced to overexpress KCNC1 when pre-incubated with $BaCl_2$, show characteristics more similar to uninduced cells.

Figure 7 is an illustration of an inducible expression vector comprising a tetracycline inducible promoter, a pcDNA4/TO vector construct and a HERG potassium ion channel gene.

Figure 8 is a graph demonstrating that induced HERG expressing cells are hyperpolarized as compared with the uninduced cell population. The addition of 100 mM potassium chloride depolarizes the HERG expressing cells to a greater extent than the uninduced cells. Induced cells are also more sensitive to 25 nM pimozide than are uninduced cells.

Figure 9 is an illustration of the CNTFR-DHR_SK_Pac_CMVTO vector construct. The 5' and 3' flanking homologous arms are indicated. The *pac* gene, which confers puromycin resistance, is flanked by a 5' SV40 promoter and a 3' poly A site as indicated. The vector also carries a cytomegalovirus immediate-early (CMV) promoter which contains and two tetracycline operator 2 ($TetO_2$) sites.

Fig. 10 is a graph demonstrating FACS analysis of cells stably transfected with CNTFR-DHR_SK_Pac_CMVTO. The cells were incubated in the presence or absence of 5 μg/ml doxycycline. Cells were stained with or without anti-human CNTFRα followed by Alexa Fluor 488 conjugated secondary antibody. A region was drawn around the live cells of the forward scatter vs. side scatterplot and all other plots were gated on this region. The negative population, density plots of uninduced samples and induced samples without primary antibody were set on the first log of FL1. Panel A shows uninduced cells, untreated with doxycyline, but stained with both primary and secondary antibodies. Panel B shows induced cells, treated with doxycycline, and only stained with secondary antibody. Panel C shows cells induced and stained with primary and secondary antibodies. Density plots of the induced sample (Panel C) show a specific increase in Alexa Fluor 488 signal as demonstrated by increased cell counts in the third log of FL1 compared to Panel A and Panel B figures.

Fig. 11 is an immunoblot analysis of STAT3 and phosphorylated STAT3 from homologous recombinant clones. Isolated clones from sorting were expanded and treated with or without CNTF for 15 minutes. One clone which did not contain homologous integration of target vector, clone #14, was used as a negative control. Two clones containing homologous integration of the target vector, clone #15 and #16, were analyzed. These cells were lysed and probed with anti-

phosphorylated STAT3 to measure STAT3 activation as a result of ligand, CNTF, treatment and anti-STAT3 to measure total STAT3.

Summary of the Invention

One aspect of the present invention includes a method for identifying molecules that modulate a target protein, comprising providing mammalian cells transfected in such a way as to provide a nucleotide sequence encoding the target under control of a heterologous inducible promoter; inducing the promoter under conditions that provide a detectable change in a measurable parameter associated with the cells; contacting at least a portion of the cells with a test compound to ascertain whether the test compound affects a change in the measurable parameter; and repeating the contacting step with at least one other test compound. Preferably, the measurable parameter is a parameter other than growth or survival. In one embodiment, the contacting step comprises contacting cells with the test compound while the promoter is induced. The method may advantageously include comprising comparing the value of the measurable parameter in uninduced cells with the value of the parameter in induced cells.

In one embodiment, the method includes testing various candidate parameters to ascertain which one is most directly or most advantageously associated with induction of the target sequence. Thus, the measurable parameter can be selected from among a plurality of candidate parameters based on the comparison.

The promoter can typically be induced to different degrees. In some cases, induction of the promoter can have a deleterious effect on cell growth or survival. Thus, the cells can be cultured and expanded without induction of the promoter, and then the promoter can be induced as part of the assay. In one embodiment, the promoter is induced to a degree that provides a detectable change in the parameter but not to a degree that kills the cell. The invention also includes empirical testing of various levels of induction to select that level that optimally provides a cell that is responsive to stimulus or provides an optimal level of signal, while maintaining that amount of viability or cell function necessary for successful performance of the assay.

Induction can occur in various ways. Thus, the methods of the invention include including the promoter by contacting the cell with an inducer molecule. They also include induction of the promoter by removal or inhibition of a repressor.

In some embodiments of the invention, the target protein affects ion channel activity of the cell. In one particular embodiment, the target protein is an ion channel protein.

In other embodiments of the invention, the target protein is a cell surface receptor, such as a G-protein coupled receptor. In still other embodiments, the target protein is another type of signaling molecule or transport molecule.

One aspect of the present invention includes identification of the type of signal being produced by a candidate molecule, or more particularly, the method by which the signal is being produced or by which the modulation occurs. Thus, the method may include identifying at least

one test compound that modulates the measurable parameter in the cell; providing a second cell line that differs from the first cell line in that the inducible promoter controls expression of a reporter instead of polynucleotide encoding target; contacting the second cell line with the identified test compound; and ascertaining whether the identified test compound affects the expression of the reporter. In this manner, one can differentiate between compounds having a genuine effect on the target, and compounds that simply modulate the activity of the inducible promoter.

The polynucleotide encoding the target can be transfected into the cell, or can be endogenous polynucleotide that is simply placed under the control of an inducible heterologous promoter that functionally replaces the endogenous promoter (if any).

The invention also includes a method for identifying an ion channel modulator molecule comprising obtaining a cell that conditionally expresses an ion channel target; incubating a potential ion channel modulator molecule with the cell; and determining whether ion flow through the ion channel targets has modulated, thereby identifying molecules that modulate the ion channel target. In one embodiment, the cell that conditionally expresses the ion channel target has been induced to express the ion channel target. Some preferred cells include CHO, CHO-K1, HEK293, COS, Vero, SH-SY5Y, and U20S cells. The cells are advantageously mammalian cells, although other cell systems may also be used. In a particular embodiment, the step of obtaining a cell that conditionally expresses an ion channel target comprises genetically adapting the cell to produce an ion channel target. The cell can be genetically adapted, for example, by transducing or transfecting the cell with an inducible vector comprising an ion channel target. The inducible vector may comprise an inducible cassette wherein the inducible cassette comprises an inducible promoter, an ion channel gene, and a gene conferring resistance to a selection agent for selecting transfected cells wherein the inducible promoter is operably linked to the ion channel gene. Suitable inducible promoters include the heat shock inducible promoter, metallothionin promoter, ecdysone-inducible promoter, FKBP dimerization inducible promoter, Gal4-estrogen receptor fusion protein regulated promoter, lac repressor, steroid inducible promoter, streptogramin responsive promoters and tetracycline regulated promoters, as well as any other compatible promoter.

One embodiment of the invention includes a method wherein the inducible vector may be activated to express the ion channel target and inactivated to prevent expression of the ion channel target. As one example, the ion channel target is an ion channel selected from the group consisting of a sodium ion channel, an epithelial sodium channel, a chloride ion channel, a voltage-gated chloride ion channel, a potassium ion channel, a voltage-gated potassium ion channel, a calcium-activated potassium channel, an inwardly rectifying potassium channel, a calcium ion channel, a voltage-gated calcium ion channel, a ligand-gated calcium ion channel, a cyclic-nucleotide gated ion channel, a hyperpolarization-activated cyclic-nucleotide gated channel, a water channel, a gap junction channel, a viral ion channel, an ATP-gated ion channel and a calcium permeable beta-amyloid peptide channel.

Yet another method of the present invention is a method for identifying an ion channel modulator molecule, comprising the steps of obtaining a cell that conditionally expresses an ion channel target; adding an inducer molecule that induces expression of the ion channel target in the cell; measuring membrane potential of the cell; incubating a potential ion channel modulator molecule with the cell; measuring changes in membrane potential; and determining whether ion flow through the ion channel targets has been modulated, thereby identifying a molecule that modulates the ion channel.

The invention also includes a method for screening chemical compounds to identify an ion channel modulator compound comprising the steps of obtaining a cell that conditionally expresses an ion channel target; adding an inducer molecule that induces expression of the ion channel target in the cell; measuring membrane potential of the cell; incubating the chemical compounds with the cell; measuring changes in membrane potential; and determining whether ion flow through the ion channel targets has been modulated, thereby identifying compounds that modulate the ion channel target.

Still another aspect of the present invention includes a method for identifying a membrane receptor modulator molecule comprising obtaining a cell that conditionally expresses a target membrane receptor; inducing expression of the target membrane receptor; measuring a physiological condition of the cell to obtain a first set of data; incubating a potential membrane receptor modulator molecule with the cell; measuring the physiological condition of the cell to obtain a second set of data; and comparing the first set of data with the second set of data to determine whether the physiological condition of the cell has been modulated, thereby identifying a molecule that modulates the target membrane receptor. The cell used in the method can be provided as a cell that contains an endogenous target membrane receptor sequence and an endogenous noncoding sequence (such as a promoter); wherein the method includes inserting an inducible cassette comprising a 5' insertion adapter, a regulatory sequence and a 3' insertion adapter within the endogenous noncoding sequence such that the regulatory sequence is operably linked such that it is able to modulate transcription of the target membrane receptor by the presence or absence of a regulator. In one embodiment, the regulatory sequence is a non-mammalian enhancer sequence or a repressor sequence. This non-mammalian enhancer sequence can, for example, be a herpes virus enhancer or an artificial enhancer. Alternatively, the non-mammalian enhancer sequence can be an inducible promoter, e.g., a herpes virus promoter or other suitable inducible promoter. In another embodiment, the regulator is VP16 or a functional domain of VP16. One method of the present invention includes transfecting the cell with a regulatory expression vector construct comprising a second inducible promoter and a regulator gene encoding the regulator operably linked such that induction of the second inducible promoter by an exogenous stimulus initiates transcription of the regulator gene. The second inducible promoter can, for example, be a tetracycline inducible promoter or an ecdysone-inducible promoter. The external

stimulus for inducing the target can be any suitable stimulus, such as, for example, tetracycline, ponasterone, dexamethasone, a heavy metal ion or heat. The step of inducing expression of the target membrane receptor can also be initiated by the presence or absence of a regulator or by the presence or absence of an inducer.

In one embodiment that uses an inducible cassette as a transfection vector, the inducible cassette further comprises a target sequence such that the target sequence is transcribed upon induction of the inducible cassette. Particularly preferred target sequences may be selected from the group consisting of a G-protein coupled receptor target sequence, a nuclear hormone receptor target sequence, a cytokine receptor target sequence, a protein kinase-coupled receptor target sequence a nicotinic acetylcholine receptor target sequence, a ionotropic glutamate receptor target sequence, a glycine receptor target sequence, a gamma-aminobutyric acid receptor target sequence, and a vanilloid receptor target sequence. One useful target sequence is 5HT4.

When repressor sequences are used, one particularly useful repressor sequence is able to bind a zinc finger protein. Advantageously, the zinc finger protein comprises a KRAB domain.

Still another method of the present invention is a method for screening a chemical compound library to identify a G-protein coupled receptor modulator molecule, comprising obtaining a cell that conditionally expresses a G-protein coupled receptor; inducing expression of the G-protein coupled receptor; measuring a physiological parameter associated with the G-protein coupled receptor to obtain a first set of data; incubating a potential modulator of the G-protein coupled receptor with the cell; measuring the physiological parameter to obtain a second set of data; and comparing the first set of data with the second set of data to determine whether the physiological parameter has been modulated, thereby identifying a chemical compound that modulates a G-protein coupled receptor. Suitable physiological parameters can include, for example, a cAMP level, a calcium level, and a membrane potential of the cell.

One particular embodiment of the invention comprises an inducible vector containing an ion channel target having a nucleotide sequence shown in SEQ. ID NO. 1, or a cell containing SEQ ID NO: 1 under control of an inducible promoter. The invention may also include an inducible expression vector comprising a tetracycline inducible promoter, a pcDNA4/TO vector construct and a human HERG potassium channel gene. Still another invention is an inducible regulatory expression vector construct comprising a subcloning vector, a second inducible promoter and a regulator gene. The present invention also includes cells transduced or transfected with any of the inducible vectors described or contemplated herein. In one embodiment, the cell is a CHO cell and the transduced or transfected cell expresses tet repressor and HERG potassium ion channel gene.

The present invention also includes ion channel modulators, membrane receptor modulators, G-protein coupled receptor modulators, and other modulators identified using the methods of the present invention.

The present invention also includes a kit comprising cells that conditionally express an ion channel target, a compound that induces expression of the ion channel target, and an indicator compound or system for indicating ion channel activity of the cells. It further includes a kit comprising cells that conditionally express an ion channel target and a fluorescent dye.

Definitions

Prior to setting forth the invention, it may be helpful to first set forth the definitions of certain terms that will be used hereinafter. All references, which have been cited below are hereby incorporated by reference in their entirety.

A "nucleic acid molecule" or "nucleic acid sequence" is a linear segment of single- or double-stranded DNA or RNA that can be isolated from any source. In the context of the present invention, the nucleic acid molecule is preferably a segment of DNA. An "isolated" nucleic acid molecule or an isolated enzyme is a nucleic acid molecule or enzyme that, by the hand of man, exists apart from its native environment and is therefore not a product of nature. An isolated nucleic acid molecule or enzyme may exist in a purified form or may exist in a non-native environment such as, for example, a recombinant host cell.

A "gene" is a defined region that is located within a genome and that, besides the aforementioned coding nucleic acid sequence, comprises other, primarily regulatory, nucleic acid sequences responsible for the control of the expression, that is to say the transcription and translation, of the coding portion. A gene may also comprise other 5' and 3' untranslated sequences and termination sequences. Further elements that may be present are, for example, introns. However, as context may require, the term "gene" can refer more simply to a sequence encoding a desired polypeptide or protein, particularly in the context of a "gene" under the control of an inducible promoter.

The term "construct" as used herein refers to a recombinant DNA sequence, generally a recombinant DNA molecule, that has been generated for the purpose of the expression of a specific nucleotide sequence(s), or is to be used in the construction of other recombinant nucleotide sequences. The construct may be generated for the purpose of controlling the expression of a specific nucleotide sequence(s) as, for example, in a construct containing a viral enhancer. In general, "construct" is used herein to refer to a recombinant DNA molecule comprising a subcloning vector and may further comprise an inducible cassette and/or a regulator gene.

The term "genetically adapting" as used herein refers to the process of establishing an inducible expression cloning vector construct within a cell such that the target sequence's expression may be exogenously controlled. The term "exogenously controlled" as used herein refers to an increase or decrease in expression of a target sequence by the presence or absence of an inducer molecule or inducing condition. The inducer molecule or inducing condition originates from outside of the host organism.

The term "transfection" refers to a process for introducing heterologous nucleic acid into a host cell or organism A transfected cell refers to a host cell, such as a eukaryotic cell, and more specifically, a mammalian cell, into which a heterologous nucleic acid molecule has been introduced. The nucleic acid molecule can be stably integrated into the genome of the host or the nucleic acid molecule and can also be present as an extrachromosomal molecule, such as a vector or plasmid. Such an extrachromosomal molecule can be auto-replicating.

The term "modulator molecule", "compound that modulates", "modulatory compound", or "compound" as used herein refers to any compound that activates, enhances, increases, decreases, or suppresses the function of an expressed target or increases or decreases the amount of an expressed target.

The term "modulation" or "modulated" as used herein refers to any change in functional activity such as activation, enhancement, increasing, interference with or suppression or an increase or decrease in the amount of expressed target.

A " modulatory molecule" can modulate the activity of the target molecule in many ways. For example, a modulator may act on a target by affecting its conformation, folding (or other physical characteristics), binding to other moieties (such as ligands), activity (or other functional characteristics), and/or other aspects of protein structure or functions is considered to have modulated polypeptide function. Any method of modifying the target activity is suitable for the present invention, as long as the modification of target activity when compared to the absence of the modulatory molecule can be assessed. Such a modulatory molecule can include small organic or inorganic molecules as well as large macromolecules. Specific examples of small molecules include KCl or $BaCl_2$. Examples of macromolecules which may be able to modulate the activity of the target of a cell include peptides, polypeptides, proteins, nucleic acid, carbohydrate and lipid. Functional or structural analogues or mimics of such compounds which exhibit substantially the same activation or inhibition activity are also included within the meaning of the term as used herein. The type, size or shape of the molecule is not important so long as the molecules can modulate the specific target activity of a cell.

The term "chemical library" or "array" refers to an intentionally created collection of differing molecules which can be prepared synthetically and screened for biological activity in a variety of different formats (e.g., libraries of soluble molecules, libraries of molecules bound to a solid support).

The term "target sequence" as used herein refers to a known DNA nucleotide sequence of a target wherein the DNA may be cDNA.

The term "target" as used herein refers to a protein of interest that has a known or suspected function or that has more than one known or suspected function. In this case, the term "function" refers to a signaling event, rather than a role in a disease state. Changes in the target's function or

functional activity when exposed to potential modulator molecules are utilized to identify modulator molecules.

The term "target binding conditions" as used herein refers to environmental conditions that may effect the interaction between a target and a modulator molecule such as pH, temperature, and salt concentration.

The term "induction" or "induced" as used herein refers to the initiation of transcription and translation of the target sequence. Induction may occur in the presence of an inducer or in the absence of a repressor.

As used herein, the term "promoter" is a DNA sequence which extends upstream from the transcription initiation site and is involved in binding of RNA polymerase. The promoter may contain several short (<10 base pair) sequence elements that bind transcription factors, generally dispersed over >200 base pairs.

The term "inducible promoter" as used herein refers to a promoter that is transcriptionally active when bound to a regulator that activates transcription or when a regulator that represses transcription is absent. The inducible promoter is operatively linked to a target sequence.

The term "conditional expression" or "conditionally expresses" as used herein refers to the ability to activate and/or suppress the transcription of a target sequence by the presence or absence of an inducer molecule, an inducing condition or a regulator molecule.

The term "operably linked" as used herein refers to a DNA sequence and regulatory sequence(s) are connected in such a way as to permit gene expression when the appropriate molecules are bound to the regulatory sequences. When the inducible promoter is regulated by a repressor, gene expression may occur in the absence of a repressor. When the inducible promoter is regulated by an environmental condition, gene expression occurs by obtaining the inducing environmental condition (*e.g.* an increase in temperature activating a heat shock promoter).

The term "inducible cassette" as used herein refers to a sequence that may be inserted into a cloning vector that allows for the exogenous control of the transcription of a target sequence.

An "indicator molecule" refers to any molecule which allows visualization of the modulation of the target. For example, fluorescent indicator dyes which display altered fluorescence characteristics upon a change in membrane potential may be used.

The term "identify", "identifying", or "identification" as used herein refers to an act of assaying a compound or a plurality of compounds using the methods of the present invention to isolate a compound or compounds that modulate function or functional activity of a target.

The term "determine", determining" or "determination" as used herein refers to the act of comparing assay measurements of a compound or compounds that may or may not have modulatory function or activity with a compound or compounds that do not have modulatory function or activity to isolate a compound or compounds that modulate a function or functional activity of a target.

As used herein, the term "physiological condition" refers to any biochemical or physiological change in the cell such that the event can be visualized using an indicator molecule according to the method of the present invention.

Detailed Description of the Invention

The present invention provides methods for identifying modulator molecules by screening these molecules against cells that conditionally express a target. In these methods cells that are clonally selected from populations stably transfected with an inducible vector construct may be controlled by the presence or absence of an exogenous cell-permeable inducer. This is especially advantageous when overexpression of the target interferes with the cell's growth or survival. Cells may be cultured in the absence of inducer to expand the population then transcription of the target sequence may be initiated for assay purposes. Assays to detect modulation may be different depending on the function of the target *e.g.* for a G-protein coupled receptor ("GPCR") modulation may result in a change in cyclic AMP or intracellular calcium levels and modulation of an ion channel may result in a change in membrane potential. Moreover, the difference in functional activity of the target before and after induction provides an indication that the target is active and creates an 'assay window' that may be monitored during screening to verify that the cell is continuing to express the target throughout the testing period.

I. Inducible Vector Construct

The inducible vector construct provides control over the transcription of a target sequence such as an ion channel or GPCR by the presence or absence of an exogenous inducer or inducing condition. Therefore, expression may be increased or decreased to a level that when modulation occurs the user is able to distinguish between compounds that activate or inhibit a target's function or functional activity. In addition the detrimental effects associated with overexpression (*e.g.* toxicity and heterogeneous expression, *e.g.* variances in expression) of cells whether from the same population or of different type may be reduced. More specifically, the present invention provides methods for assaying transfected cells prior to induction ("steady state") and after induction ("activated state") of an inducible cassette. A measurement may also be taken once induction has ceased, and the transfected cells have returned to steady state. Steady state may be achieved by the absence of the inducer molecule or inducing condition or by the presence of a repressor such that the target sequence is unable to be transcribed. As previously described, current methods of modulator molecule discovery are unable to achieve conditions that allow for measurement of an initial steady state condition and an activated state condition. In addition, current methods are unable to monitor target activity during the course of a testing period.

The inducible vector construct may advantageously comprise an inducible cassette and a subcloning vector such as a plasmid or a cosmid. The inducible cassette regulates the expression of a target sequence positioned within the cassette by the induction of an inducible promoter positioned upstream of the target sequence. This induction occurs by adding an inducer molecule,

removing a repressor, or changing an environmental condition that initiates transcription at the inducible promoter. Therefore, the user is able to exogenously "turn on" or "turn off" expression of the target sequence, and is advantageously also able to fine tune the level of expression.

Some examples of inducible vector constructs that may be used are the tetracycline-dependent systems (Invitrogen, Carlsbad, CA; Clontech, Palo Alto CA) and the ecdysone inducible vector (Invitrogen, Carlsbad, CA). For example, the vector illustrated in Figure 1 may be used for the present invention. The construct contains a region allowing regulated expression from a cytomegalovirus enhancer-promoter sequence containing two copies of the tet-O2 sequence, which is an enhancer that allows for highly regulated expression of the inserted gene. The vector additionally contains a gene conferring antibiotic (ampicillin) resistance, which is useful for bacterial subcloning procedures, and another gene conferring resistance to selection agents (such as zeocin) after transfection into the eukaryotic host cell. The construct of Figure 1 also contains a multiple cloning site allowing for gene insertion downstream of the CMV tet-O2 promoter-enhancer sequence.

One embodiment of the inducible cassette comprises an inducible promoter, a selecting sequence, and a target insertion domain able to accept at least one target sequence. The inducible cassette may further comprise a reporter gene and/or at least one restriction site to enable ligation of the inducible cassette into a subcloning vector.

As an alternative to the use of the inducible cassette, an inducible promoter (and preferably also a gene providing for resistance to selection agents) can be inserted into the genome of a cell in which the target gene is endogenous. This would typically involve the use of 5' and 3' adapters enabling insertion of the inducible cassette into the host's genome by homologous recombination.

The inducible promoter provides exogenous control over the transcription of the target sequence by the presence or absence of an inducer molecule, a repressor, or an environmental condition that initiates transcription. A promoter may be selected based on a variety of characteristics such as its efficiency at initiating transcription, its ability to be exogenously controlled, the availability of its corresponding inducer and by the characteristics of the target.

The rate and efficiency of transcription by a given inducible promoter will vary depending on the promoter and its response to its corresponding inducer. Different inducible promoters are able to initiate transcription at different efficiencies and have different response curves to the absence or presence of their corresponding inducers. When the precise level of expression within the cell is to be quantitatively controlled a promoter with a rapid response to inducer may be desired (*e.g.* a minimal CMV promoter with two Tet-operator sequences 5' of the promoter (as, for example, in the T-Rex system, Invitrogen, Carlsbad, CA). However, when precise control is not desired a promoter with basal activity may be utilized.

The availability of an inducer molecule may be regulated by biological accessibility or economic concerns. The ability for an inducer to be available biologically in an assay system may

depend on its concentration, affinity and specificity. Correspondingly, the cost for obtaining a sufficient supply of inducer may be economically unfeasible. Tetracycline and its more stable analogue doxycycline are readily available inducers that may be utilized with the present invention. However, when the selecting sequence of the inducible cassette comprises a tetracycline resistance gene, a tetracycline inducible promoter may not be desired because the addition of the corresponding selecting media would also initiate transcription of the target sequence thereby reducing control over expression.

Cellular effects, such as for example cell growth or apoptosis, resulting from an expressed target may be a factor when choosing an inducible promoter. Steady state may be achieved when the promoter is "turned on" or "turned off" consequently promoters that are "turned on" in their steady state may be better suited for targets that do not interfere with cell survival or that inhibit deleterious effects such as for example apoptosis. Alternatively, promoters that are "turned off" in their steady state may be better suited for targets that interfere with cell growth, such as certain ion channels or apoptosis activators.

Some examples of promoters useful in the present invention are heat shock inducible promoter, metallothionin promoter, ecdysone-inducible promoter, FKBP dimerization inducible promoter, Gal4-estrogen receptor, fusion protein regulated promoter, Lac repressor, steroid inducible promoter, streptogramin responsive promoters, and tetracycline regulated promoters.

Selection is performed to select for cells that have been transfected with the inducible target construct. Mammalian cell transfection selection typically utilizes genes encoding resistance to selective agents such as, for example, zeocin, hygromycin, blasticidin, and geneticin.

The choice of a selecting sequence may depend on a variety of characteristics. The choice of a selecting sequence may depend on the ability to provide resistance to more than one selection agent. A selecting gene that confers resistance to a variety of selecting media may be desired to allow flexibility in the selecting procedure. Similarly, the addition of multiple selecting sequences may be combined into one cassette allowing the user to choose either for selection purposes.

The selecting sequence may be any sequence that allows selection of cells that express an inducible construct from those that do not following transfection. Selection may be conducted by addition of a selecting media that requires the expression of the selecting sequence for cell survival. Generally the selecting sequence may be an antibiotic resistance gene conferring resistance to its corresponding antibiotic or a gene that expresses a nutrient necessary for cell survival in a nutrient deficient culture media. Alternatively, single cells may be selected using fluorescent activated cell sorting ("FACS") when the selecting sequence encodes a fluorescent protein such as, for example, a green fluorescent protein ("GFP").

When choosing a selecting sequence for the inducible cassette it is preferable that the subcloning vector comprise a functionally different selecting sequence, so that the selection would not be specific to a construct comprising the inducible cassette. Correspondingly, when choosing a

selecting sequence for the inducible cassette, it is preferable that the selecting sequence not provide resistance against an inducer.

One skilled in the art will recognize that when a cell is engineered to express different inducible cassettes, a different selection sequence may be inserted into each inducible cassette, allowing selection for cells able to express each. For example, zeocin resistance may be the selection sequence for one cassette, while hygromycin resistance may be the selection sequence for the second cassette. Therefore, when both are transfected into a cell, the appropriate media may contain zeocin and hygromycin. Some examples of selecting sequences useful in the present invention are genes that confer resistance to the selective agents zeocin, hygromycin and geneticin. Alternatively, nucleotide sequences that encode essential nutrients absent in nutrient deficient media may be utilized as selection sequences.

The target insertion domain is a sequence of nucleotides that enables ligation or insertion of a target sequence within the inducible cassette. The target insertion domain may comprise a single cloning site or a multiple cloning site ("MCS") and may further comprise a reporter gene allowing detection of recombinant clones. Alternatively the target insertion domain may comprise thymidine overhangs enabling PCR products to be directly ligated to the cloning vector and may further comprise a reporter gene allowing detection of recombinant clones (Current Protocols in Molecular Biology, John Wiley Press).

In addition, a reporter gene may be positioned outside of the target insertion domain such that expression of the reporter occurs when the inducible cassette is expressed within the subcloning vector. In this configuration for example a luciferase reporter gene may be utilized to detect insertion of the inducible cassette into the subcloning vector. Other reporter genes that may be utilized with the present invention are b-galactosidase, chloramphenicol acetyltransferase and green fluorescent protein.

The inducible cassette may also comprise 5' and 3' insertion adapters enabling it to be inserted into the genome of the host organism by homologous recombination using standard recombination techniques (Mansour *et al., Nature*, 336:348-352,1988). In this configuration the insertion adapters are complementary to the non-coding region of the genome where the inducible cassette is to be inserted. Transcription of the target sequence may be controlled directly by the inducer or may be controlled through an intermediary whereby the inducer initiates transcription at an inducible promoter positioned within a second construct ("regulatory construct") which may express a regulator. The regulator in this configuration controls the transcription of the target sequence.

The target sequence may be any nucleic acid sequence that encodes a cellular protein of pharmaceutical interest. The target sequence may be a known or a previously unidentified sequence. Known sequences may be selected by searching a database such as GenBank or SwissProt. Once the sequence of interest is selected primers may be designed such that the

sequence may be amplified from a cDNA library (Current Protocols in Molecular Biology, John Wiley Press). Alternatively, the sequence may be purchased or obtained from a collection such as the I.M.A.G.E. Consortium [LLNL] cDNA Clones, (Lennon *et al.*, *Genomics* 33:151-152, 1996). The cDNA clones provided by the I.M.A.G.E. Consortium are available through distributors including the ATCC (Rockville, MD). The target sequence may encode a membrane-associated protein such as an ion channel protein, a receptor such as a G-protein coupled receptor target sequence, a nuclear hormone receptor target sequence, a cytokine receptor target sequence and a protein kinase-coupled receptor target sequence, a soluble protein such as an enzyme. A list of ion channel proteins that may be encoded by the target sequence of the present invention is listed in Table I, below.

Table I

Name	Description of Ion Channel
ACCN1	ACCN; amiloride-sensitive cation channel 1, Neuronal (degenerin); MDEG; BNC1; BnaC1; hBNaC1; Hs.6517
ACCN2	Amiloride-sensitive cation channel 2, neuronal; BNaC2; hBNaC2
ACCN3	TNAC1; ASIC3; amiloride-sensitive cation channel 3, testis
AQP1	Aquaporin 1 (channel-forming integral protein, 28kD); Hs.96074; CHIP28; Hs.74602
BEC1	Ether-a-go-go K(+) channel family member
BEC2	Ether-a-go-go K(+) channel family member
CACC2	Calcium-dependent chloride channel 2
CACNA1A	CACNL1A4; EA2; MHP1; SCA6; calcium channel, voltage-dependent, P/Q type, alpha 1A subunit; APCA; Acetazolamide responsive hereditary paroxysmal cerebellar ataxia; HPCA; familial periodic cerebellar ataxia/ hereditary paroxysmal cerebellar ataxia/ episodic ataxia; spinocerebellar ataxia 6; MHP; FHM; migraine, hemiplegic 1
CACNA1B	CACNL1A5; CACNN; calcium channel, voltage-dependent, alpha 1B subunit, N type; calcium channel, N type
CACNA1C	CACNL1A1; calcium channel, voltage-dependent, L type, alpha 1C subunit; CCHL1A1
CACNA1D	CACNL1A2; calcium channel, voltage-dependent, L type, alpha 1D subunit; CCHL1A2
CACNA1E	CACNL1A6; calcium channel, voltage-dependent, alpha 1E subunit
CACNA1F	Calcium channel, voltage-dependent, alpha 1F subunit; congenital stationary night blindness 2; CSNB2; CSNXB2
CACNA1G	NBR13; calcium channel, voltage-dependent, T type, alpha-1G subunit
CACNA1H	Calcium channel, voltage-dependent, alpha 1H subunit
CACNA1I	Calcium channel, voltage-dependent, alpha 1I subunit
CACNA1S	CACNL1A3; MHS5; calcium channel, voltage-dependent, L type, alpha 1S subunit; malignant hyperthermia susceptibility 5; HypoPP; HOKPP; calcium channel, L type, alpha 1 polypeptide, isoform 3 (skeletal muscle, hypokalemic periodic paralysis)
CACNA2D1	CACNA2; CACNL2A; MHS3; calcium channel, voltage-dependent, alpha 2/delta subunit; malignant hyperthermia susceptibility 3

Name	Description of Ion Channel
CACNA2D2	CACNA2D; KIAA0558; calcium channel, voltage-dependent, alpha 2/delta subunit 2
CACNB1	CACNLB1; calcium channel,voltage-dependent, beta 1 subunit
CACNB2	CACNLB2; MYSB; calcium channel,voltage-dependent, beta 2 subunit; myasthenic (Lambert-Eaton) syndrome antigen B
CACNB3	CACNLB3; calcium channel,voltage-dependent, beta 3 subunit
CACNB4	Calcium channel, voltage-dependent, beta 4 subunit
CACNG1	CACNG; CACNLG; calcium channel,voltage-dependent, gamma subunit
CACNG2	Calcium channel, voltage-dependent, gamma subunit 2
CACNG3	Calcium channel, voltage-dependent, gamma subunit 3
CLCA1	Chloride channel, calcium activated, 1; CaCC
CLCA2	Chloride channel, calcium activated, 2
CLCA3	Chloride channel, calcium activated, family member 3
CLCN1	CLC1; chloride channel 1, skeletal muscle (Thomsen disease, autosomal dominant)
CLCN2	Chloride channel 2; ClC-2
CLCN3	Chloride channel 3; ClC-3
CLCN4	Chloride channel 4; Hs.32790; ClC-4
CLCN5	NPHL2; chloride channel 5; Hs.3121; DENTS; nephrolithiasis 2 (X-linked, Dent disease)
CLCN6	Chloride channel 6; ClC-6; KIAA0046
CLCN7	Chloride channel 7; ClC-7; CLC7
CLCNKA	Chloride channel Ka; hClC-Ka
CLCNKB	Chloride channel Kb; hClC-Kb; Bartter syndrome, Type 3
CLIC1	Chloride intracellular channel 1; NCC27; p64CLCP
CLIC2	Chloride intracellular channel 2
CLIC3	Chloride intracellular channel 3
CLIC4	Chloride intracellular channel 4; chloride intracellular channel 4 (mitochondrial); H1; huH1; mc3s5; p64H1; mtCLIC; CLIC4L
CLIC5	Chloride intracellular channel 5
CLIC6	CLIC5; chloride intracellular channel 6; chloride intracellular channel 5; CLICL1
CLNS1A	CLCI; chloride channel, nucleotide-sensitive, 1A; Icln
CLNS1B	Chloride channel, nucleotide-sensitive, 1B; Icln
CNGA1	CNCG1; cyclic nucleotide gated channel alpha 1; CNG1; RCNC1; RCNCalpha; CNCG
CNGA2	CNCA1; cyclic nucleotide gated channel alpha 2; CNG2; OCNC1; OCNCa; OCNCalpha; CNCA
CNGA3	CNCG3; cyclic nucleotide gated channel alpha 3; CCNC1; CNG3; CCNCa; CCNCalpha
CNGB1	CNCG2; CNCG3L; cyclic nucleotide gated channel beta 1; RCNC2; Hs.93909; GARP; GAR1; RCNCb; RCNCbeta; cyclic nucleotide gated channel (photoreceptor), cGMP gated 3 (gamma)-like
CNGB2	CNCA2; cyclic nucleotide gated channel beta 2; OCNC2; OCNCbeta
CNGB3	Cyclic nucleotide gated channel beta 3; ACHM3; achromatopsia-3; Pingelapese colorblindness

Name	Description of Ion Channel
HCN1	BCNG1; hyperpolarization activated cyclic nucleotide-gated potassium channel 1; brain cyclic nucleotide gated channel 1; HAC-2; BCNG-1
HCN2	BCNG2; hyperpolarization activated cyclic nucleotide-gated potassium channel 2; brain cyclic nucleotide gated channel 2; HAC-1; BCNG-2
HCN4	Hyperpolarization activated cyclic nucleotide-gated potassium channel 4
KCNA1	RBK1; HUK1; MBK1; AEMK; KV1.1; potassium voltage-gated channel, shaker-related subfamily, member 1 (episodic ataxia with myokymia)
KCNA10	Potassium voltage-gated channel, shaker-related subfamily, member 10
KCNA2	Potassium voltage-gated channel, shaker-related subfamily, member 2; HK4; KV1.2
KCNA3	Hs.1750; MK3; HLK3; HPCN3; KV1.3; potassium voltage-gated channel, shaker-related subfamily, member 3
KCNA4	Hs.89647; Hs.1854; HK1; HPCN2; KV1.4; potassium voltage-gated channel, shaker-related subfamily, member 4
KCNA4L	Potassium voltage-gated channel, shaker-related subfamily, member 4-like
KCNA5	Hs.89509; HK2; HPCN1; KV1.5; potassium voltage-gated channel, shaker-related subfamily, member 5
KCNA6	Hs.2715; HBK2; KV1.6; potassium voltage-gated channel, shaker-related subfamily, member 6
KCNA7	HAK6; K()1.7; potassium voltage-gated channel, shaker-related subfamily, member 7
	KCNA1B; potassium voltage-gated channel, shaker-related subfamily, member 1 beta-1 subunit
KCNAB2	KCNA2B; potassium voltage-gated channel, shaker-related subfamily, member 1 beta-2 subunit
KCNAB3	KCNA3B; potassium voltage-gated channel, shaker-related subfamily, beta member 3
KCNB1	KV2.1; potassium voltage-gated channel, Shab-related subfamily, member 1
KCNB2	Potassium voltage-gated channel, Shab-related subfamily, member 2
KCNC1	KV3.1; potassium voltage-gated channel, Shaw-related subfamily, member 1
KCNC2	KV3.2; potassium voltage-gated channel, Shaw-related subfamily, member 2
KCNC3	K()3.3; potassium voltage-gated channel, Shaw-related subfamily, member 3
KCNC4	KV3.4; HKSHIIIC; potassium voltage-gated channel, Shaw-related subfamily, member 4
KCND1	Potassium voltage-gated channel, Shal-related subfamily, member 1; KV4.1
KCND2	Potassium voltage-gated channel, Shal-related subfamily, member 2; RK5; KV4.2
KCND3	Potassium voltage-gated channel, Shal-related subfamily, member 3; KV4.3; KSHIVB
KCNE1	Potassium voltage-gated channel, Isk-related family, member 1; minK; LQT5; ISK
KCNE2	Potassium voltage-gated channel, Isk-related family, member 2; LQT5; LQT6; MiRP1
KCNE3	Potassium voltage-gated channel, Isk-related family, member 3; MIRP2
KCNF1	KCNF; KV5.1; potassium voltage-gated channel, subfamily F
KCNG1	KCNG; KV6.1; potassium voltage-gated channel, subfamily G
KCNH1	Potassium voltage-gated channel, subfamily H, member 1

Name	Description of Ion Channel
KCNH2	LQT2; long (electrocardiographic) QT syndrome 2; potassium voltage-gated channel, subfamily H, member 2; HERG; human ether-a-go-go-related gene
KCNJ1	Potassium inwardly-rectifying channel, subfamily J, member 1; ROMK1; Kir1.1; Hs.463
KCNJ10	Potassium inwardly-rectifying channel, subfamily J, member 10; Kir4.1; Kir1.2; KCNJ13-PEN
KCNJ11	Potassium inwardly-rectifying channel, subfamily J, member 11; BIR; Kir6.2
KCNJ12	Potassium inwardly-rectifying channel, subfamily J, member 12; Kir2.2
KCNJ13	Potassium inwardly-rectifying channel,subfamily J, member 13; Kir1.4; Kir7.1
KCNJ14	Potassium inwardly-rectifying channel,subfamily J, member 14; IRK4; Kir2.4
KCNJ15	Potassium inwardly-rectifying channel, subfamily J, member 15; Kir4.2; Kir1.3; KCNJ14-PEN
KCNJ16	Potassium inwardly-rectifying channel, subfamily J, member 16; Kir5.1
KCNJ2	Potassium inwardly-rectifying channel, subfamily J, member 2; IRK1; Kir2.1; Hs.1547
KCNJ3	GIRK1; potassium inwardly-rectifying channel, subfamily J, member 3; Kir3.1
KCNJ4	Potassium inwardly-rectifying channel, subfamily J, member 4; HIR; HRK1; HIRK2; Kir2.3
KCNJ5	CIR; KATP1; potassium inwardly-rectifying channel, subfamily J, member 5; GIRK4; Kir3.4
KCNJ6	Potassium inwardly-rectifying channel, subfamily J, member 6; KCNJ7; GIRK2; KATP2; BIR1; Kir3.2; Hs.11173
KCNJ8	Potassium inwardly-rectifying channel, subfamily J, member 8; Kir6.1
KCNJ9	Potassium inwardly-rectifying channel, subfamily J, member 9; G-protein coupled potassium inwardly-rectifying channel subfamily, member 3; GIRK3; Kir3.3
KCNJN1	Potassium inwardly-rectifying channel, subfamily J, inhibitor 1; Kir2.2v
KCNK1	Potassium inwardly-rectifying channel, subfamily K, member 1; DPK; TWIK-1
KCNK2	Potassium inwardly-rectifying channel, subfamily K, member 2; TREK-1
KCNK3	Potassium inwardly-rectifying channel, subfamily K, member 3; TASK
KCNK5	TASK-2; potassium channel, subfamily K, member 5 (TASK-2)
KCNK6	TOSS; TWIK-2; potassium channel, subfamily K, member 6 (TWIK-2)
KCNK7	Potassium channel, subfamily K, member 7
KCNMA1	SLO; potassium large conductance calcium-activated channel, subfamily M, alpha member 1; Hs.62679
KCNMB1	Potassium large conductance calcium-activated channel, subfamily M, beta member 1; hslo-beta
KCNMB2	Potassium large conductance calcium-activated channel, subfamily M, beta member 2
KCNMB3	KCNMBL; potassium large conductance calcium-activated channel, subfamily M, beta member 3
KCNMB3L	KCNMBLP; potassium large conductance calcium-activated channel, subfamily M, beta member 3-like
KCNN1	Potassium intermediate/small conductance calcium-activated channel, subfamily N, member 1; SK1; hSK1
KCNN2	Potassium intermediate/small conductance calcium-activated channel, subfamily N, member 2; hSK2

Name	Description of Ion Channel
KCNN3	Potassium intermediate/small conductance calcium-activated channel, subfamily N, member 3; hSK3; SKCA3
KCNN4	Potassium intermediate/small conductance calcium-activated channel, subfamily N, member 4; hSK4; hKCa4; hIKCa1
KCNQ1	KCNA9; LQT1; KCNA8; potassium voltage-gated channel, KQT-like subfamily, member 1; LQTS; KVLQT1; LQT; long (electrocardiographic) QT syndrome, Ward-Romano syndrome 1
KCNQ2	Potassium voltage-gated channel, KQT-like subfamily, member 2
KCNQ3	Potassium voltage-gated channel, KQT-like subfamily, member 3
KCNQ4	DFNA2; potassium voltage-gated channel, KQT-like subfamily, member 4; deafness, autosomal dominant 2
KCNS1	Potassium voltage-gated channel, delayed-rectifier, subfamily S, member 1; Kv9.1
KCNS2	Potassium voltage-gated channel, delayed-rectifier, subfamily S, member 2; Kv9.2
KCNS3	Potassium voltage-gated channel, delayed-rectifier, subfamily S, member 3; Kv9.3
KVB3	KVB3-LSB; potassium channel beta-subunit 3
P2RX1	Purinergic receptor P2X, ligand-gated ion channel, 1
P2RX2	P2X2; purinergic receptor P2X, ligand-gated ion channel, 2
P2RX3	Purinergic receptor P2X, ligand-gated ion channel, 3; P2X3
P2RX4	Purinergic receptor P2X, ligand-gated ion channel, 4; P2X4
P2RX5	Purinergic receptor P2X, ligand-gated ion channel, 5; P2X5
P2RX7	Purinergic receptor P2X, ligand-gated ion channel, 7
SCN10A	Sodium channel, voltage-gated, type X, alpha polypeptide
SCN11A	Sodium channel, voltage-gated, type XI, alpha polypeptide
SCN12A	Sodium channel, voltage-gated, type XII, alpha polypeptide
SCN1A	SCN1; sodium channel, voltage-gated, type I, alpha polypeptide
SCN1B	Hs.89634; sodium channel, voltage-gated, type I, beta polypeptide; Hs.1969
SCN2A1	SCN2A; HBSCI; sodium channel, voltage-gated, type II, alpha 1 polypeptide
SCN2A2	HBSCII; sodium channel, voltage-gated, type II, alpha 2 polypeptide
SCN2B	Sodium channel, voltage-gated, type II, beta polypeptide
SCN3A	Sodium channel, voltage-gated, type III, alpha polypeptide
SCN4A	HYKPP; HYPP; hyperkalemic periodic paralysis (Gamstorp disease, adynamia episdica hereditaria); sodium channel, voltage-gated, type IV, alpha polypeptide
SCN4B	Sodium channel, voltage-gated, type IV, beta polypeptide
SCN5A	LQT3; sodium channel, voltage-gated, type V, alpha polypeptide (long (electrocardiographic) QT syndrome 3)
SCN6A	SCN7A; Hs.99945; sodium channel, voltage-gated, type VI, alpha polypeptide; sodium channel, voltage-gated, type VII, alpha polypeptide
SCN8A	MED; sodium channel, voltage-gated, type VIII, alpha polypeptide; motor endplate disease
SCN9A	Sodium channel, voltage-gated, type IX, alpha polypeptide
SCNN1A	SCNN1; sodium channel, nonvoltage-gated 1 alpha; EnaCa
SCNN1B	Sodium channel, nonvoltage-gated 1, beta (Liddle syndrome); EnaCb
SCNN1D	Sodium channel, nonvoltage-gated 1, delta; dNaCh; EnaCd
SCNN1G	Sodium channel, nonvoltage-gated 1, gamma; EnaCg

Name	Description of Ion Channel
TRPC1	Hs.78849; transient receptor potential channel 1
TRPC2	Transient receptor potential channel 2
TRPC3	Transient receptor potential channel 3
TRPC4	Transient receptor potential channel 4
TRPC5	Transient receptor potential channel 5
TRPC6	Transient receptor potential channel 6; TRP6
TRPC7	Transient receptor potential channel 7
VDAC1	Hs.2060; voltage-dependent anion channel 1
VDAC1LP	Voltage-dependent anion channel 1-like pseudogene
VDAC1P	Voltage-dependent anion channel 1 pseudogene
VDAC2	Voltage-dependent anion channel 2; Hs.78902
VDAC3	Voltage-dependent anion channel 3; HD-VDAC3; voltage-dependent anion channel 3
VDAC4	Voltage-dependent anion channel 4
VDAC5P	VDAC3; voltage-dependent anion channel 3

Furthermore, the target sequence may encode an entire protein or merely an active portion of the protein. For example, the full length estrogen receptor or the isolated ligand binding domain of the same receptor may be used. A list of enzymes that may be encoded by the target sequence of the present invention is presented in Table II.

Table II

Name	Description of Enzyme
AACP	arylamide acetylase pseudogene; NATP
AADAC	arylacetamide deacetylase (esterase); DAC
AANAT	arylalkylamine N-acetyltransferase; SNAT
AARS	alanyl-tRNA synthetase; Hs.75102
AATK	apoptosis-associated tyrosine kinase; AATYK; KIAA0641
ABAT	GABAT; 4-aminobutyrate aminotransferase
ABCA4	"ABCR; STGD1; ATP-binding cassette, sub-family A (ABC1), member 4; ATP binding cassette transporter; retinitis pigmentosa 19 (autosomal recessive); rim protein; FFM; STGD; ARMD2; Stargardt disease 1 (fundus flavimaculatus, autosomal recessive)"
ABCE1	"RNS4I; RNASELI; ATP-binding cassette, sub-family E (OABP), member 1; ribonuclease L (2',5'-oligoisoadenylate synthetase-dependent) inhibitor; OABP; RLI"
ABCG1	"ATP-binding cassette, sub-family G (WHITE), member 1; WHITE1; white (Drosophila) homolog 1, ATP binding casette transporter superfamily; ABC8; WHITE"
ABO	"ABO blood group (transferase A, alpha 1-3-N-actylgalactosaminyltransferase; transferase B, alpha 1-3-galactosyltransferase); Hs.95985; ABO blood type"
ABP1	Hs.75741; AOC1; DAO; amiloride binding protein 1 (amine oxidase (copper-containing))
ACAA1	ACAA; Hs.76260; acetyl-Coenzyme A acyltransferase (peroxisomal 3-oxoacyl-Coenzyme A thiolase)

Name	Description of Enzyme
ACAA2	DSAEC; acetyl-Coenzyme A acyltransferase 2 (mitochondrial 3-oxoacyl-Coenzyme A thiolase)
ACACA	ACAC; acetyl-Coenzyme A carboxylase alpha; ACC
ACACB	acetyl-Coenzyme A carboxylase beta; HACC275
ACAD	"acyl-Coenzyme A dehydrogenase, multiple"
ACADL	"Hs.1209; acyl-Coenzyme A dehydrogenase, long chain"
ACADM	"Hs.79158; MCAD; acyl-Coenzyme A dehydrogenase, C-4 to C-12 straight chain"
ACADS	"Hs.73966; acyl-Coenzyme A dehydrogenase, C-2 to C-3 short chain; SCAD"
ACADSB	"Hs.81934; acyl-Coenzyme A dehydrogenase, short/branched chain"
ACADVL	"VLCAD; LCACD; acyl-Coenzyme A dehydrogenase, very long chain"
ACAT1	Hs.37; T2; ACAT; THIL; acetyl-Coenzyme A acetyltransferase 1 (acetoacetyl Coenzyme A thiolase)
ACAT2	acetyl-Coenzyme A acetyltransferase 2 (acetoacetyl Coenzyme A thiolase)
ACE	DCP1; angiotensin I converting enzyme (peptidyl-dipeptidase A) 1; dipeptidyl carboxypeptidase 1 (angiotensin I converting enzyme); DCP; ACE1; Hs.76368; Hs.89639; Hs.99974
ACE2	angiotensin I converting enzyme (peptidyl-dipeptidase A) 2
ACHAP	acetylcholinesterase-associated protein
ACHE	acetylcholinesterase (YT blood group); Hs.89881; YT
ACK	activated p21cdc42Hs kinase
ACLY	ATP citrate lyase
ACO1	"aconitase 1, soluble"
ACO2	"aconitase 2, mitochondrial; Hs.75900"
ACOX1	"ACOX; acyl-Coenzyme A oxidase 1, palmitoyl; acyl-Coenzyme A oxidase; PALMCOX"
ACOX2	"acyl-Coenzyme A oxidase 2, branched chain; BRCACOX; branched-chain acyl-CoA oxidase, peroxisomal; BRCOX"
ACOX3	"acyl-Coenzyme A oxidase 3, pristanoyl"
ACP1	"Hs.75393; acid phosphatase 1, soluble"
ACP2	"Hs.75589; acid phosphatase 2, lysosomal"
ACP5	"Hs.89806; acid phosphatase 5, tartrate resistant; Hs.1211"
ACPP	"Hs.1852; acid phosphatase, prostate"
ACVR1	"ACVRLK2; activin A receptor, type I; SKR1; ALK2; activin A receptor, type II-like kinase 2"
ACY1	Hs.79; aminoacylase 1
ACY1L	AN; 91184800; aminoacylase 1-like
ACYP1	"acylphosphatase 1, erythrocyte (common) type; ACYPE"
ACYP2	"acylphosphatase 2, muscle type"
AD2	"Alzheimer disease 2 (APOEE4-associated, late onset)"
AD5	Alzheimer disease 5; AD5-PEN
ADA	Hs.1217; adenosine deaminase
ADAM1	FTNAP; PH-30A; a disintegrin and metalloproteinase domain 1 (fertilin alpha)
ADAM10	a disintegrin and metalloprotease domain 10; kuz
ADAM11	"MDC; metalloproteinase-like, disintegrin-like, cysteine-rich protein"

Name	Description of Enzyme
ADAM12	a disintegrin and metalloproteinase domain 12 (meltrin alpha); MLTN; MCMP; Mltna
ADAM13	a disintegrin and metalloproteinase domain 13
ADAM14	ADM-1; a disintegrin and metalloproteinase domain 14
ADAM15	a disintegrin and metalloproteinase domain 15 (metargidin); MDC15
ADAM16	MDC16; a disintegrin and metalloproteinase domain 16
ADAM18	ADAM27; TMDCIII; a disintegrin and metalloproteinase domain 18
ADAM19	MLTNB; a disintegrin and metalloproteinase domain 19 (meltrin beta)
ADAM20	a disintegrin and metalloproteinase domain 20
ADAM21	a disintegrin and metalloproteinase domain 21
ADAM22	a disintegrin and metalloproteinase domain 22; MDC2
ADAM23	a disintegrin and metalloproteinase domain 23; MDC-L; MDC3
ADAM24	a disintegrin and metalloproteinase domain 24
ADAM25	a disintegrin and metalloproteinase domain 25
ADAM26	a disintegrin and metalloproteinase domain 26
ADAM28	a disintegrin and metalloproteinase domain 28
ADAM29	a disintegrin and metalloproteinase domain 29; svph1
ADAM30	a disintegrin and metalloproteinase domain 30; svph4
ADAM3B	CYRN2; cyritestin 2; a disintegrin and metalloproteinase domain 3b (cyritestin 2)
ADAM4	TMDCV; a disintegrin and metalloproteinase domain 4
ADAM5	TMDCII; a disintegrin and metalloproteinase domain 5
ADAM6	TMDCIV; a disintegrin and metalloproteinase domain 6
ADAM7	EAPI; GP-83; a disintegrin and metalloproteinase domain 7
ADAM8	a disintegrin and metalloprotease domain 8
ADAM9	a disintegrin and metalloproteinase domain 9 (meltrin gamma); MCMP; MCMP-PEN; ADAM12; myeloma cell metalloproteinase
ADAMTS1	"a disintegrin-like and metalloprotease (reprolysin type) with thrombospondin type 1 motif, 1; METH1; METH-1"
ADAMTS2	"a disintegrin-like and metalloprotease (reprolysin type) with thrombospondin type 1 motif, 2; PCINP; hPCPNI; ADAM-TS2; ADAMTS-3; EDS VIIC; EDS VIIB"
ADAMTS4	"a disintegrin-like and metalloprotease (reprolysin type) with thrombospondin type 1 motif, 4; ADMP-1; ADAMTS-2"
ADAMTS5	"a disintegrin-like and metalloprotease (reprolysin type) with thrombospondin type 1 motif, 5 (aggrecanase-2); ADMP-2; ADAMTS11"
ADAMTS6	"ADAM-TS6; a disintegrin-like and metalloprotease (reprolysin type) with thrombospondin type 1 motif, 6"
ADAMTS7	"ADAM-TS7; a disintegrin-like and metalloprotease (reprolysin type) with thrombospondin type 1 motif, 7"
ADAMTS8	"METH2; a disintegrin-like and metalloprotease (reprolysin type) with thrombospondin type 1 motif, 8"
ADAR	"Hs.7957; adenosine deaminase, RNA-specific"
ADARB1	"adenosine deaminase, RNA-specific, B1 (homolog of rat RED1); ADAR2"
ADARB2	"adenosine deaminase, RNA-specific, B2 (homolog of rat BLUE); RED2; hRED2"
ADAT1	"adenosine deaminase, tRNA-specific 1; hADAT1"

Name	Description of Enzyme
ADCP1	adenosine deaminase complexing protein 1
ADCY1	Hs.139; adenylate cyclase 1 (brain)
ADCY2	HBAC2; adenylate cyclase 2 (brain)
ADCY3	adenylate cyclase 3
ADCY4	adenylate cyclase 4
ADCY5	adenylate cyclase 5
ADCY6	adenylate cyclase 6
ADCY7	KIAA0037; adenylate cyclase 7
ADCY8	Hs.2522; ADCY3; HBAC1; adenylate cyclase 8 (brain)
ADCY9	adenylate cyclase 9
ADCYAP1	Hs.68137; PACAP; adenylate cyclase activating polypeptide 1 (pituitary)
ADCYAP1R1	PACAPR; adenylate cyclase activating polypeptide 1 (pituitary) receptor type 1
ADE2C1	ade2 (S.cerevisiae) complementing; Multifunctional SAICAR synthetase/AIR carboxylase
ADE2H1	multifunctional polypeptide similar to SAICAR synthetase and AIR carboxylase
ADH1	"Hs.73843; alcohol dehydrogenase 1 (class I), alpha polypeptide"
ADH2	"Hs.4; alcohol dehydrogenase 2 (class I), beta polypeptide"
ADH3	"Hs.2523; alcohol dehydrogenase 3 (class I), gamma polypeptide"
ADH4	"Hs.1219; alcohol dehydrogenase 4 (class II), pi polypeptide"
ADH5	"Hs.78989; alcohol dehydrogenase 5 (class III), chi polypeptide"
ADH5P1	"alcohol dehydrogenase 5 (class III), chi polypeptide, pseudogene 1"
ADH6	alcohol dehydrogenase 6 (class V)
ADH7	"alcohol dehydrogenase 7 (class IV), mu or sigma polypeptide; Hs.389"
ADK	Hs.94382; adenosine kinase
ADPRH	ADP-ribosylarginine hydrolase
ADPRT	ADP-ribosyltransferase (NAD+; poly (ADP-ribose) polymerase); PARP; Hs.76105; PPOL
ADPRTL1	ADP-ribosyltransferase (NAD+; poly (ADP-ribose) polymerase)-like 1; PH5P; PARPL; VPARP; KIAA0177
ADPRTL2	ADP-ribosyltransferase (NAD+; poly(ADP-ribose) polymerase)-like 2; Adprt2; PARP-2
ADPRTL3	ADP-ribosyltransferase (NAD+; poly (ADP-ribose) polymerase)-like 3; PARP-2
ADPRTP1	PPOLP1; ADP-ribosyltransferase (NAD+; poly (ADP-ribose) polymerase) pseudogene 1
ADPRTP2	PPOLP2; ADP-ribosyltransferase (NAD+; poly (ADP-ribose) polymerase) pseudogene 2
ADRBK1	"Hs.83636; GRK2; BARK1; adrenergic, beta, receptor kinase 1"
ADRBK2	"GRK3; BARK2; adrenergic, beta, receptor kinase 2"
ADSL	adenylosuccinate lyase; adenylosuccinase
ADSS	adenylosuccinate synthase
AFG3L1	"AFG3 (ATPase family gene 3, yeast)-like 1; AFG3"
AFG3L2	"AFG3 (ATPase family gene 3, yeast)-like 2"
AGA	Hs.21488; aspartylglucosaminidase
AGL	"Hs.904; amylo-1,6-glucosidase, 4-alpha-glucanotransferase (glycogen debranching enzyme, glycogen storage disease type III)"

Name	Description of Enzyme
AGPAT1	"1-acylglycerol-3-phosphate O-acyltransferase 1 (lysophosphatidic acid acyltransferase, alpha); LPAAT-ALPHA; G15; lysophosphatidic acid acyltransferase alpha"
AGPS	alkylglycerone phosphate synthase; ADHAP; ADHAP-PEN; alkyl-dihydroxyacetonephosphate; ADAS; ADPS; ADHAPS; ADAP-S; ALDHPSY
AGXT	SPAT; Hs.81554; alanine-glyoxylate aminotransferase (oxalosis I; hyperoxaluria I; glycolicaciduria; serine-pyruvate aminotransferase)
AHCY	Hs.85111; S-adenosylhomocysteine hydrolase
AHCYL1	XPVKONA; S-adenosylhomocysteine hydrolase-like 1
AHHR	AHH; aryl hydrocarbon hydroxylase regulator
AIED	"OA2; Aland island eye disease (Forsius-Eriksson ocular albinism, ocular albinism type 2)"
AK1	adenylate kinase 1
AK2	adenylate kinase 2
AK3	adenylate kinase 3
AK3P1	adenylate kinase 3 pseudogene 1
AKAP1	"AKAP84; AKAP84-PEN; A kinase anchor protein(spermatid, p84)"
AKAP10	D-AKAP2; AKAP10-PENDING; A kinase (PRKA) anchor protein 10
AKAP11	A kinase (PRKA) anchor protein 11; AKAP 220; KIAA0629
AKAP13	BRX; HT31; AKAP13-PENDING; A kinase (PRKA) anchor protein 13
AKAP2	AKAP-KL; KIAA0920; AKAP2-PENDING; DKFZP564L0716; A kinase (PRKA) anchor protein 2
AKAP3	SOB1; AKAP110; AKAP3-PENDING; A kinase (PRKA) anchor protein 3
AKAP4	P82; FSC1; AKAP82; HAKAP82; AKAP4-PENDING; A kinase (PRKA) anchor protein 4
AKAP5	AKAP75; AKAP79; AKAP5-PENDING; A kinase (PRKA) anchor protein 5
AKAP7	AKAP18; AKAP7-PENDING; A kinase (PRKA) anchor protein 7
AKAP8	AKAP95; AKAP8-PENDING; DKFZP586B1222; A kinase (PRKA) anchor protein 8
AKAP9	YOTIAO; CG-NAP; AKAP450; AKAP350; AKAP120; KIAA0803; A kinase (PRKA) anchor protein 9
AKR1A1	"aldo-keto reductase family 1, member A1 (aldehyde reductase); ALR"
AKR1B1	"ALDR1; aldo-keto reductase family 1, member B1 (aldose reductase); aldehyde reductase 1 (low Km aldose reductase); Hs.75313; AR"
AKR1C1	"DDH1; dihydrodiol dehydrogenase 1 (trans-1,2-dihydrobenzene-1,2-diol dehydrogenase, high affinity bile acid binding); Hs.78183; DDH; MBAB"
AKR1C2	"DDH2; dihydrodiol dehydrogenase 2 (trans-1,2-dihydrobenzene-1,2-diol dehydrogenase)"
AKR1C3	"aldo-keto reductase family 1, member C3 (3-alpha hydroxysteroid dehydrogenase, type II); KIAA0119"
AKR1C4	CHDR; chlordecone reductase; Hs.76790
AKR1D1	"SRD5B1; aldo-keto reductase family 1, member D1 (delta 4-3-ketosteroid-5-beta-reductase); steroid-5-beta-reductase, beta polypeptide 1 (3-oxo-5 beta-steroid delta 4-dehydrogenase beta 1)"
AKR7A2	"aldo-keto reductase family 7, member A2 (aflatoxin aldehyde reductase); AFAR; AKR7"
AKR7A3	"aldo-keto reductase family 7, member A3 (aflatoxin aldehyde reductase)"

Name	Description of Enzyme
AKT3	"v-akt murine thymoma viral oncogene homolog 3 (protein kinase B, gamma); protein kinase B gamma; PKBG; PRKBG; RAC-gamma"
ALAD	"aminolevulinate, delta-, dehydratase"
ALAS1	"Hs.78712; ALAS; aminolevulinate, delta-, synthase 1; Hs.2530"
ALAS2	"Hs.79103; ASB; aminolevulinate, delta-, synthase 2 (sideroblastic/hypochromic anemia)"
ALDH1	"aldehyde dehydrogenase 1, soluble; Hs.76392; PUMB1"
ALDH10	SLS; aldehyde dehydrogenase 10 (fatty aldehyde dehydrogenase); Sjogren-Larsson syndrome; FALDH
ALDH2	"Hs.74630; aldehyde dehydrogenase 2, mitochondrial"
ALDH3	Hs.575; aldehyde dehydrogenase 3
ALDH4	aldehyde dehydrogenase 4 (glutamate gamma-semialdehyde dehydrogenase; pyrroline-5-carboxylate dehydrogenase); P5CDh
ALDH5	ALDHX; aldehyde dehydrogenase 5
ALDH5A1	SSADH; NAD+-dependent succinic semialdehyde dehydrogenase; SSDH
ALDH6	Hs.75746; aldehyde dehydrogenase 6
ALDH7	aldehyde dehydrogenase 7 (NOTE: redefinition of symbol); Hs.3116; ALDH4; Hs.2533
ALDH8	aldehyde dehydrogenase 8; Hs.87539
ALDH9	"aldehyde dehydrogenase 9 (gamma-aminobutyraldehyde dehydrogenase, E3 isozyme)"
ALDOA	"Hs.75181; aldolase A, fructose-bisphosphate"
ALDOAP1	"aldolase A, fructose-bisphosphate pseudogene 1"
ALDOAP2	"aldolase A, fructose-bisphosphate pseudogene 2"
ALDOB	"aldolase B, fructose-bisphosphate; Hs.75592; ALDO2"
ALDOC	"aldolase C, fructose-bisphosphate"
ALDRL1	aldehyde reductase (aldose reductase)-like 1
ALDRL2	aldehyde reductase (aldose reductase)-like 2
ALDRL3	aldehyde reductase (aldose reductase)-like 3
ALDRL4	aldehyde reductase (aldose reductase)-like 4
ALDRP	aldehyde reductase (aldose reductase) pseudogene
ALK	anaplastic lymphoma kinase (Ki-1)
ALOX12	arachidonate 12-lipoxygenase; Hs.1200
ALOX12B	"arachidonate 12-lipoxygenase, 12R type"
ALOX12P1	ALOX12P; arachidonate 12-lipoxygenase pseudogene 1
ALOX12P2	arachidonate 12-lipoxygenase pseudogene 2
ALOX15	arachidonate 15-lipoxygenase; Hs.73809
ALOX15B	"arachidonate 15-lipoxygenase, second type"
ALOX5	arachidonate 5-lipoxygenase; Hs.89499
ALOX5AP	arachidonate 5-lipoxygenase-activating protein; FLAP
ALPI	"alkaline phosphatase, intestinal"
ALPL	"alkaline phosphatase, liver/bone/kidney; Hs.2241; HOPS; TNSALP; tissue-nonspecific ALP"
ALPP	"Hs.73847; alkaline phosphatase, placental (Regan isozyme)"
ALPPL2	"alkaline phosphatase, placental-like 2"
AMD1	Hs.75744; S-adenosylmethionine decarboxylase 1

Name	Description of Enzyme
AMD2	S-adenosylmethionine decarboxylase 2 (pseudogene); AMD; S-adenosylmethionine decarboxylase 2
AMPD1	adenosine monophosphate deaminase 1 (isoform M)
AMPD2	adenosine monophosphate deaminase 2 (isoform L)
AMPD3	Hs.83918; adenosine monophosphate deaminase 3 (isoform E)
AMT	Hs.102; aminomethyltransferase (glycine cleavage system protein T)
AMY1A	"AMY1; amylase, alpha 1A; salivary"
AMY1B	"AMY1; amylase, alpha 1B; salivary"
AMY1C	"AMY1; amylase, alpha 1C; salivary"
AMY2A	"AMY2; amylase, alpha 2A; pancreatic"
AMY2B	"AMY2; amylase, alpha 2B; pancreatic"
AMYP1	"AMY2P; amylase, alpha pseudogene 1"
ANG	"angiogenin, ribonuclease, RNase A family, 5; RNASE5"
ANPEP	"Hs.1239; PEPN; CD13; alanyl (membrane) aminopeptidase (aminopeptidase N, aminopeptidase M, microsomal aminopeptidase, CD13, p150)"
ANXA2	"ANX2; CAL1H; arylsulfatase B; Hs.74470; LIP2; LPC2D; ANX2L4; annexin II (lipocortin II); calpactin I, heavy polypeptide (p36)"
ANXA3	"ANX3; Hs.1378; annexin III (lipocortin III, 1,2-cyclic-inositol-phosphate phosphodiesterase, placental anticoagulant protein III, calcimedin 35-alpha)"
AOAH	Hs.82542; acyloxyacyl hydrolase (neutrophil)
AOC2	"amine oxidase, copper containing 2 (retina-specific); RAO; DAO2"
AOC3	"VAP-1; amine oxidase, copper containing 3 (vascular adhesion protein 1)"
AOE372	thioredoxin peroxidase (antioxidant enzyme)
AOX1	aldehyde oxidase 1; AO
APAA	N-acetylglucosamine-1-phosphodiester alpha-N-acetylglucosaminidase; LOC51172
APAF1	apoptotic protease activating factor 1; CED4
APC10	DOC1; anaphase-promoting complex 10
APEH	D3S48E; Hs.78223; N-acylaminoacyl-peptide hydrolase
APEX	APE; APEX nuclease (multifunctional DNA repair enzyme); REF1; HAP1; apurinic/apyrimidinic (abasic) endonuclease
APP	"amyloid beta (A4) precursor protein (protease nexin-II, Alzheimer disease); Hs.74600; AD1"
APRT	adenine phosphoribosyltransferase
APT6M8-9	"ATPase, H+ transporting, lysosomal (vacuolar proton pump) membrane sector associated protein M8-9"
AR	androgen receptor (dihydrotestosterone receptor; testicular feminization; spinal and bulbar muscular atrophy; Kennedy disease); Hs.99915; DHTR; SBMA; AIS; NR3C4; Hs.1241
ARD1	"TE2; N-acetyltransferase, homolog of S. cerevisiae ARD1"
ARG1	"Hs.77600; arginase, liver"
ARG2	"arginase, type II; Hs.79338"
ARHGAP1	Rho GTPase activating protein 1; RhoGAP; p50rhoGAP
ARHGAP4	Rho GTPase activating protein 4; KIAA0131; C1; p115; RhoGAP4
ARHGAP5	Rho GTPase activating protein 5; p190-B; RhoGAP5
ARHGAP6	Rho GTPase activating protein 6; rhoGAPX-1
ARSA	Hs.88251; arylsulfatase A

Name	Description of Enzyme
ARSB	arylsulfatase B; Hs.1256
ARSC2	"ARSC; arylsulfatase C, isozyme F"
ARSD	arylsulfatase D; Hs.43887
ARSDP	arylsulfatase D pseudogene
ARSE	CDPX; CDPX1; arylsulfatase E (chondrodysplasia punctata 1)
ARSEP	arylsulfatase E pseudogene
ARSF	arylsulfatase F
ART1	ADP-ribosyltransferase 1; ART2
ART2P	RT6; ADP-ribosyltransferase 2 pseudogene (RT6 antigen (rat) homolog); ART1P
ART3	ADP-ribosyltransferase 3; ADP-ribosyltransferase 3
ART4	ADP-ribosyltransferase 4
ASAH	N-acylsphingosine amidohydrolase; AC
ASK	activator of S phase kinase
ASL	Hs.61258; argininosuccinate lyase
ASLL	argininosuccinate lyase-like
ASM3A	acid sphingomyelinase-like phosphodiesterase
ASMT	acetylserotonin O-methyltransferase; HIOMT
ASMTL	acetylserotonin N-methyltransferase-like
ASNS	asparagine synthetase
ASNSL1	asparagine synthetase-like 1
ASNSL2	asparagine synthetase-like 2
ASPA	"aspartoacylase (aminoacylase 2, Canavan disease); Hs.32042; ASP"
ASPH	aspartate beta-hydroxylase
ASS	"argininosuccinate synthetase; Hs.76753; ASS1; CTLN1; citrullinemia, classic"
ASSP1	argininosuccinate synthetase pseudogene 1
ASSP10	argininosuccinate synthetase pseudogene 10
ASSP11	argininosuccinate synthetase pseudogene 11
ASSP12	argininosuccinate synthetase pseudogene 12
ASSP13	argininosuccinate synthetase pseudogene 13
ASSP14	argininosuccinate synthetase pseudogene 14
ASSP2	argininosuccinate synthetase pseudogene 2
ASSP3	argininosuccinate synthetase pseudogene 3
ASSP4	argininosuccinate synthetase pseudogene 4
ASSP5	argininosuccinate synthetase pseudogene 5
ASSP6	argininosuccinate synthetase pseudogene 6
ASSP7	argininosuccinate synthetase pseudogene 7
ASSP8	argininosuccinate synthetase pseudogene 8
ASSP9	argininosuccinate synthetase pseudogene 9
ATE1	arginyltransferase 1
ATIC	5-aminoimidazole-4-carboxamide ribonucleotide formyltransferase/IMP cyclohydrolase; PURH; AICARFT/IMPCHASE
ATP-BL	"ATP synthase, subunit b-like"
ATP1A1	"ATPase, Na+/K+ transporting, alpha 1 polypeptide"
ATP1A2	"ATPase, Na+/K+ transporting, alpha 2 (+) polypeptide"

Name	Description of Enzyme
ATP1A3	"ATPase, Na+/K+ transporting, alpha 3 polypeptide"
ATP1AL1	"Hs.1165; ATPase, Na+/K+ transporting, alpha polypeptide-like 1"
ATP1AL2	"ATPase, Na+/K+ transporting, alpha polypeptide-like 2; ATP1A4"
ATP1B1	"ATPase, Na+/K+ transporting, beta 1 polypeptide; Hs.78629; ATP1B"
ATP1B2	"ATPase, Na+/K+ transporting, beta 2 polypeptide; Hs.90792; AMOG; Hs.78854"
ATP1B3	"ATPase, Na+/K+ transporting, beta 3 polypeptide"
ATP1B3P1	"ATPase, Na+/K+ transporting, beta 3 pseudogene 1"
ATP1B4	"B4 ATPase, (Na+)/K+ transporting, beta 4 polypeptide; X,K-ATPase beta-m subunit"
ATP1BL1	"ATPase, Na+/K+ transporting, beta polypeptide-like 1"
ATP1G1	"ATPase, Na+/K+ transporting, gamma 1 polypeptide"
ATP2A1	"ATP2A; SERCA1; ATPase, Ca++ transporting, cardiac muscle, fast twitch 1"
ATP2A2	"DAR; Darier disease (keratosis follicularis); ATPase, Ca++ transporting, cardiac muscle, slow twitch 2; Hs.1526; ATP2B; SERCA2"
ATP2A3	"ATPase, Ca++ transporting, ubiquitous"
ATP2B1	"PMCA1; ATPase, Ca++ transporting, plasma membrane 1"
ATP2B2	"ATPase, Ca++ transporting, plasma membrane 2 (NOTE: redefinition of symbol); Hs.89512; PMCA2"
ATP2B3	"Hs.2009; PMCA3; ATPase, Ca++ transporting, plasma membrane 3"
ATP2B4	"Hs.995; PMCA4; ATP2B2; ATPase, Ca++ transporting, plasma membrane 4"
ATP3	"ATPase, Mg++ transporting"
ATP4A	"ATP6A; ATPase, H+/K+ transporting, alpha polypeptide"
ATP4B	"ATP6B; ATPase, H+/K+ transporting, beta polypeptide"
ATP5	"ATP synthase, H+ transporting, mitochondrial; Hs.73851; ATPM; ATP5A"
ATP5A1	"ATP5A; ATP synthase, H+ transporting, mitochondrial F1 complex, alpha subunit, isoform 1, cardiac muscle; Hs.1182; OMR; ATPM"
ATP5A2	"ATP synthase, H+ transporting, mitochondrial F1 complex, alpha subunit, isoform 2, non-cardiac muscle"
ATP5AL1	"ATP synthase, H+ transporting, mitochondrial F1 complex, alpha subunit, isoform 1, cardiac muscle-like 1"
ATP5AL2	"ATP synthase, H+ transporting, mitochondrial F1 complex, alpha subunit, isoform 2, non-cardiac muscle-like 2"
ATP5AP1	"ATP synthase, H+ transporting, mitochondrial F1 complex, alpha subunit, pseudogene 1"
ATP5AP2	"ATP synthase, H+ transporting, mitochondrial F1 complex, alpha subunit, pseudogene 2"
ATP5AP3	"ATP synthase, H+ transporting, mitochondrial F1 complex, alpha subunit, pseudogene 3"
ATP5B	"Hs.25; ATPSB; ATP synthase, H+ transporting, mitochondrial F1 complex, beta polypeptide"
ATP5BL1	"ATPSBL1; ATP synthase, H+ transporting, mitochondrial F1 complex, beta polypeptide-like 1"
ATP5BL2	"ATPSBL2; ATP synthase, H+ transporting, mitochondrial F1 complex, beta polypeptide-like 2"
ATP5C1	"ATP5C; ATP synthase, H+ transporting, mitochondrial F1 complex, gamma polypeptide 1"

Name	Description of Enzyme
ATP5C2	"ATP synthase, H+ transporting, mitochondrial F1 complex, gamma polypeptide 2"
ATP5CL1	"ATP synthase, H+ transporting, mitochondrial F1 complex, gamma polypeptide-like 1"
ATP5CL2	"ATP synthase, H+ transporting, mitochondrial F1 complex, gamma polypeptide-like 2"
ATP5D	"Hs.89761; ATP synthase, H+ transporting, mitochondrial F1 complex, delta subunit"
ATP5E	"ATP synthase, H+ transporting, mitochondrial F1 complex, epsilon subunit"
ATP5EP1	"ATP synthase, H+ transporting, mitochondrial F1 complex, epsilon subunit pseudogene 1"
ATP5F1	"Hs.77199; ATP synthase, H+ transporting, mitochondrial F0 complex, subunit b, isoform 1"
ATP5G1	"ATP synthase, H+ transporting, mitochondrial F0 complex, subunit c (subunit 9), isoform 1; ATP5G"
ATP5G2	"ATP synthase, H+ transporting, mitochondrial F0 complex, subunit c (subunit 9), isoform 2"
ATP5G3	"ATP synthase, H+ transporting, mitochondrial F0 complex, subunit c (subunit 9) isoform 3"
ATP5GP1	"ATP synthase, H+ transporting, mitochondrial F0 complex, subunit c (subunit 9) pseudogene 1"
ATP5H	"ATP synthase, H+ transporting, mitochondrial F0 complex, subunit d"
ATP5I	"ATP synthase, H+ transporting, mitochondrial F0 complex, subunit e (? oligomycin sensitivity conferring protein)"
ATP5J	"ATP synthase, H+ transporting, mitochondrial F0 complex, subunit F6"
ATP5J2	"ATP5JL; F1FO-ATPASE; ATP5J2-PENDING; ATP synthase, H+ transporting, mitochondrial F0 complex, subunit f, isoform 2"
ATP5JD	"ATP synthase, H+ transporting, mitochondrial F1F0, subunit d"
ATP5JG	"ATP synthase, H+ transporting, mitochondrial F1F0, subunit g"
ATP5O	"ATP synthase, H+ transporting, mitochondrial F1 complex, O subunit (oligomycin sensitivity conferring protein); Hs.76572; OSCP; ATPO"
ATP6A1	"Hs.52210; VPP2; ATPase, H+ transporting, lysosomal (vacuolar proton pump), alpha polypeptide, 70kD, isoform 1"
ATP6A2	"Hs.603; VPP2; ATPase, H+ transporting, lysosomal (vacuolar proton pump), alpha polypeptide, 70kD, isoform 2"
ATP6B1	"ATPase, H+ transporting, lysosomal (vacuolar proton pump), beta polypeptide, 56/58kD, isoform 1; Hs.1009; VPP3; V-ATPASE; VATB"
ATP6B2	"ATPase, H+ transporting, lysosomal (vacuolar proton pump), beta polypeptide, 56/58kD, isoform 2; Hs.56298; VPP3; Hs.1697"
ATP6C	"Hs.76159; ATPL; ATPase, H+ transporting, lysosomal (vacuolar proton pump) 16kD"
ATP6D	"Hs.86905; ATPase, H+ transporting, lysosomal (vacuolar proton pump) 42kD"
ATP6DV	"vacuolar proton-ATPase, subunit D; V-ATPase, subunit D"
ATP6E	"Hs.77805; ATPase, H+ transporting, lysosomal (vacuolar proton pump) 31kD; Hs.74105"
ATP6EL1	"ATPase, H+ transporting, lysosomal (vacuolar proton pump) 31kD-like 1"
ATP6EP1	"ATPase, H+ transporting, lysosomal (vacuolar proton pump) 31kD pseudogene 1"

Name	Description of Enzyme
ATP6EP2	"ATPase, H+ transporting, lysosomal (vacuolar proton pump) 31kD pseudogene 2"
ATP6F	"ATPase, H+ transporting, lysosomal (vacuolar proton pump) 21kD"
ATP6G	"ATPase, H+ transporting, lysosomal (vacuolar proton pump)"
ATP6H	"ATPase, H+ transporting, lysosomal (vacuolar proton pump) 9kD"
ATP6J	"ATPase, H+ transporting, lysosomal (vacuolar proton pump), member J; ATP6GL"
ATP6N1A	"ATP6N1; ATPase, H+ transporting, lysosomal (vacuolar proton pump) non-catalytic accessory protein 1A (110/116kD); VPP1; vacuolar proton pump, subunit 1"
ATP6N2	"ATPase, H+ transporting, lysosomal (vacuolar proton pump) non-catalytic accessory protein 2 (38kD)"
ATP6S1	"ATPase, H+ transporting, lysosomal (vacuolar proton pump), subunit 1; ORF; XAP-3; VATPS1; 16A"
ATP6S14	"ATPase, vacuolar, 14 kD"
ATP7A	"Hs.606; MNK; ATPase, Cu++ transporting, alpha polypeptide (Menkes syndrome)"
ATP7B	"ATPase, Cu++ transporting, beta polypeptide (Wilson disease); Hs.84999; WND"
ATPC2B	"ATPASEP; ATPase, class 2, member b; ATPase type IV, phospholipid transporting (P-type)(putative)"
ATPP2	ATPASEII; aminophospholipid translocase
ATRN	attractin (with dipeptidylpeptidase IV activity)
AUH	AU RNA-binding protein/enoyl-Coenzyme A hydratase
AXL	Hs.83341; AXL receptor tyrosine kinase
B3GALT1	"UDP-Gal:betaGlcNAc beta 1,3-galactosyltransferase, polypeptide 1; BETA3GAL-T1"
B3GALT2	"beta-1,3-glucuronyltransferase 2 (glucuronosyltransferase S); BETA3GAL-T2; UDP-Gal:betaGlcNAc beta 1,3-galactosyltransferase, polypeptide 2; GlcAT-S"
B3GALT3	"BETA3GAL-T3; UDP-Gal:betaGlcNAc beta 1,3-galactosyltransferase, polypeptide 3"
B3GALT4	"BETA3GAL-T4; UDP-Gal:betaGlcNAc beta 1,3-galactosyltransferase, polypeptide 4"
B3GALT5	"UDP-Gal:betaGlcNAc beta 1,3-galactosyltransferase, polypeptide 5; beta3Gal-T5"
B4GALT1	GGTB2; Hs.80881; glycoprotein-4-beta-galactosyltransferase 2
B4GALT2	"UDP-Gal:betaGlcNAc beta 1,4- galactosyltransferase, polypeptide 2; beta4Gal-T2"
B4GALT3	"BETA4GAL-T3; UDP-Gal:betaGlcNAc beta 1,4- galactosyltransferase, polypeptide 3"
B4GALT4	"BETA4GAL-T4; UDP-Gal:betaGlcNAc beta 1,4- galactosyltransferase, polypeptide 4"
B4GALT5	"UDP-Gal:betaGlcNAc beta 1,4- galactosyltransferase, polypeptide 5; beta4GalT-V; beta4-GalT IV"
B4GALT6	"UDP-Gal:betaGlcNAc beta 1,4- galactosyltransferase, polypeptide 6"
B4GALT7	"xylosylprotein beta1,4-galactosyltransferase, polypeptide 7 (galactosyltransferase I); XGPT1; XGALT-1; beta4Gal-T7"

Name	Description of Enzyme
B99	GTSE-1; Hs.122552; Gtse1 (mouse) homolog; GTSE1; G two S phase expressed protein 1
BAAT	BAT; bile acid Coenzyme A: amino acid N-acyltransferase (glycine N-choloyltransferase)
BAP1	BRCA1 associated protein-1 (ubiquitin carboxy-terminal hydrolase); ubiquitin carboxy-terminal hydrolase
BBOX	"BBH; G-BBH; GAMMA-BBH; butyrobetaine (gamma), 2-oxoglutarate dioxygenase (gamma-butyrobetaine hydroxylase)"
BCAT1	"BCT1; branched chain aminotransferase 1, cytosolic"
BCAT2	"BCT2; branched chain aminotransferase 2, mitochondrial"
BCHE	butyrylcholinesterase; E1; CHE1
BCHEL1	butyrylcholinesterase-like 1; CHEL1
BCHEL3	butyrylcholinesterase-like 3; CHEL3
BCKDHA	"Hs.78950; branched chain keto acid dehydrogenase E1, alpha polypeptide (maple syrup urine disease)"
BCKDHB	"Hs.1265; branched chain keto acid dehydrogenase E1, beta polypeptide (maple syrup urine disease)"
BCKDK	branched chain alpha-ketoacid dehydrogenase kinase
BCPM	benign chronic pemphigus (Hailey-Hailey disease)
BDH	"3-hydroxybutyrate dehydrogenase (heart, mitochondrial)"
BETA3GNT	"beta-1,3-N-acetylglucosaminyltransferase"
BETA3GNTI	"i-beta-1,3-N-acetylglucosaminyltransferase"
BHMT	betaine-homocysteine methyltransferase
BLK	B lymphoid tyrosine kinase; Hs.2243
BLMH	bleomycin hydrolase
BLVRA	BLVR; biliverdin reductase A
BLVRB	biliverdin reductase B
BMPR1A	"ACVRLK3; bone morphogenetic protein receptor, type IA; ALK3; activin A receptor, type II-like kinase 3"
BMPR2	"bone morphogenetic protein receptor, type II (serine/threonine kinase); BRK-3; T-ALK; BMPR3; BMPR-II"
BMX	BMX non-receptor tyrosine kinase; ETK; PSCTK2
BPGM	"Hs.79537; 2,3-bisphosphoglycerate mutase"
BPHL	biphenyl hydrolase-like (serine hydrolase); D0S2254E; MCNAA; Bph-rp
BPNT1	"3'(2'), 5'-bisphosphate nucleotidase 1"
BTD	Hs.78885; biotinidase
BTK	Bruton agammaglobulinemia tyrosine kinase; ATK; XLA; IMD1; AGMX1; PSCTK1
CA1	Hs.23118; carbonic anhydrase I
CA10	carbonic anhydrase X
CA11	carbonic anhydrase XI; CARP2
CA12	carbonic anhydrase XII
CA2	Hs.89748; carbonic anhydrase II; Hs.78883
CA3	"carbonic anhydrase III, muscle specific"
CA4	carbonic anhydrase IV; Hs.89485; CAIV
CA5A	"CA5; carbonic anhydrase VA, mitochondrial; carbonic anhydrase V, mitochondrial; Hs.137; CAV; CAVA"

Name	Description of Enzyme
CA5B	"carbonic anhydrase VB, mitochondrial"
CA5P	carbonic anhydrase V pseudogene
CA6	Hs.73855; carbonic anhydrase VI
CA7	carbonic anhydrase VII
CA8	carbonic anhydrase VIII; CALS; CARP
CA9	carbonic anhydrase IX; MN
CAD	"carbamoyl-phosphate synthetase 2, aspartate transcarbamylase, and dihydroorotase"
CALM1	"calmodulin 1 (phosphorylase kinase, delta); Hs.73785; CAMI; PHKD; DD132; CALML2"
CALM1P1	"calmodulin 1 (phosphorylase kinase, delta) pseudogene 1"
CALM1P2	"calmodulin 1 (phosphorylase kinase, delta) pseudogene 2"
CALM2	"PHKD; CAMII; calmodulin 2 (phosphorylase kinase, delta)"
CALM3	"PHKD; calmodulin 3 (phosphorylase kinase, delta)"
CAMK1	calcium/calmodulin-dependent protein kinase I; CAMK1-PEN; CaMKI
CAMK2A	CAMKA; calcium/calmodulin-dependent protein kinase (CaM kinase) II alpha; KIAA0968
CAMK2B	CAMKB; calcium/calmodulin-dependent protein kinase (CaM kinase) II beta
CAMK2D	CAMKD; calcium/calmodulin-dependent protein kinase (CaM kinase) II delta; CaMKII delta
CAMK2G	CAMKG; calcium/calmodulin-dependent protein kinase (CaM kinase) II gamma
CAMK4	calcium/calmodulin-dependent protein kinase IV; Hs.348
CAMKK1	"calcium/calmodulin-dependent protein kinase kinase 1, alpha; CaMKKa"
CAMKK2	"calcium/calmodulin-dependent protein kinase kinase 2, beta; CaMKK; CaMKKb; KIAA0787"
CANPX	calpain-like protease
CAP1	"CAP1-PEN; adenylyl cyclase-associated CAP protein, yeast homolog"
CAP2	adenylyl cyclase-associated protein 2
CAPN7	calpain 7; calpain like protease; PalBH
CARKL	carbohydrate kinase-like
CARM1	coactivator-associated arginine methyltransferase-1
CARS	Hs.16642; cysteinyl-tRNA synthetase
CASK	calcium/calmodulin-dependent serine protein kinase (MAGUK family)
CASKP	calcium/calmodulin-dependent serine protein kinase (MAGUK family) pseudogene
CASP1	"IL1BC; caspase 1, apoptosis-related cysteine protease (interleukin 1, beta, convertase); Hs.2490; ICE"
CASP10	"caspase 10, apoptosis-related cysteine protease; MCH4"
CASP13	"caspase 13, apoptosis-related cysteine protease; ERICE"
CASP2	"NEDD2; caspase 2, apoptosis-related cysteine protease (neural precursor cell expressed, developmentally down-regulated 2); ICH1"
CASP3	"CPP32B; caspase 3, apoptosis-related cysteine protease; Yama; CPP32; apopain"
CASP4	"caspase 4, apoptosis-related cysteine protease; TX; ICH-2; ICErel-II"
CASP5	"caspase 5, apoptosis-related cysteine protease; ICErel-III"
CASP6	"caspase 6, apoptosis-related cysteine protease; MCH2"

Name	Description of Enzyme
CASP7	"caspase 7, apoptosis-related cysteine protease; MCH3; CMH-1; ICE-LAP3"
CASP8	"caspase 8, apoptosis-related cysteine protease; MACH; MCH5; FLICE"
CASP9	"caspase 9, apoptosis-related cysteine protease; APAF3; MCH6; ICE-LAP6"
CAT	Hs.76359; catalase
CAXIV	CA13; carbonic anhydrase 13
CBR1	CBR; carbonyl reductase 1; Hs.88778; carbonyl reductase (NADPH)
CBR3	carbonyl reductase 3
CBS	cystathionine-beta-synthase; Hs.84152
CCAL1	"CPDD; chondrocalcinosis 1 (calcium pyrophosphate-deposition disease, early onset osteoarthritis)"
CCAL2	"chondrocalcinosis 2 (calcium pyrophosphate-deposition disease, without osteoarthritis)"
CCBL1	"cysteine conjugate-beta lyase; cytoplasmic (glutamine transaminase K, kyneurenine aminotransferase)"
CCO	central core disease of muscle
CCS	copper chaperone for superoxide dismutase
CDA	Hs.72924; CDD; cytidine deaminase
CDC20	"cell division cycle 20, S.cerevisiae homolog; p55CDC; protein kinase associated protein, similar to s. cerevisiae cell division cycle proteins Cdc20 and Cdc4; P55CDC-LSB"
CDC2L5	cell division cycle 2-like 5 (cholinesterase-related cell division controller); CDC2L; CHED
CDC42BPA	MRCK; MRCKA; CDC42-binding protein kinase alpha (DMPK-like)
CDC42BPB	MRCKB; CDC42-binding protein kinase beta (DMPK-like)
CDC42GA1	CDC42GA1-PEN; CDC42 GTPase activating protein 1
CDK10	"PISSLRE; protein kinase, serine/threonine cdc2-related"
CDK2	Hs.99981; cyclin-dependent kinase 2; Hs.19192
CDK3	cyclin-dependent kinase 3
CDK4	PSK-J3; cyclin-dependent kinase 4
CDK5	Hs.2869; PSSALRE; cyclin-dependent kinase 5
CDK5R1	"cyclin-dependent kinase 5, regulatory subunit 1 (p35); CDK5P35; p35; Nck5a; p35nck5a"
CDK5R2	"cyclin-dependent kinase 5, regulatory subunit 2 (p39); cyclin-dependent kinase 5, regulatory subunit 2 (p39); p39; p39nck5ai"
CDK6	cyclin-dependent kinase 6; Hs.38481; PLSTIRE
CDK7	Hs.83088; CAK1; CDKN7; cyclin-dependent kinase 7 (homolog of Xenopus MO15 cdk-activating kinase); STK1
CDK8	cyclin-dependent kinase 8; K35
CDK9	CDC2L4; cyclin-dependent kinase 9 (CDC2-related kinase); PITALRE; TAK; C-2k
CDKL1	1 cyclin-dependent kinase-like 1 (CDC2-related kinase); KKIALRE
CDKL2	cyclin-dependent kinase-like 2 (CDC2-related kinase); P56; KKIAMRE; cyclin-dependent kinase-like 2 (CDC2-related kinase)
CDKN1A	"cyclin-dependent kinase inhibitor 1A (p21, Cip1); Hs.74984; P21; CIP1; WAF1; SDI1; CDKN1; CAP20"
CDKN1B	"KIP1; P27KIP1; cyclin-dependent kinase inhibitor 1B (p27, Kip1)"
CDKN1C	"P57; KIP2; cyclin-dependent kinase inhibitor 1C (p57, Kip2)"

Name	Description of Enzyme
CDKN2A	"CDKN2; cyclin-dependent kinase inhibitor 2A (melanoma, p16, inhibits CDK4); CDK4I; MLM; Hs.1174; P16; INK4; MTS1; CMM2"
CDKN2B	"P15; MTS2; INK4B; cyclin-dependent kinase inhibitor 2B (p15, inhibits CDK4)"
CDKN2C	"INK4C; cyclin-dependent kinase inhibitor 2C (p18, inhibits CDK4)"
CDKN2D	"cyclin-dependent kinase inhibitor 2D (p19, inhibits CDK4); INK4D"
CDKN3	cyclin-dependent kinase inhibitor 3 (CDK2-associated dual specificity phosphatase); KAP; CDI1
CDO1	cysteine dioxygenase type I; Hs.3229
CDS1	CDP-diacylglycerol synthase (phosphatidate cytidylyltransferase) 1
CDS2	CDP-diacylglycerol synthase (phosphatidate cytidylyltransferase) 2
CEL	Hs.99918; BSSL; carboxyl ester lipase (bile salt-stimulated lipase)
CELL	Hs.257; carboxyl ester lipase-like (bile salt-stimulated lipase-like)
CEPT1	choline/ethanolaminephosphotransferase
CES1	CES2; carboxylesterase 1 (monocyte/macrophage serine esterase 1); carboxylesterase 2 (liver); SES1; Hs.76688; HMSE; HMSE1
CES2	"carboxylesterase 2 (intestine, liver); intestinal carboxylesterase; liver carboxylesterase-2; iCE; CE-2; hCE-2"
CH25H	cholesterol 25-hydroxylase; C25H
CHAT	choline acetyltransferase
CHD1	chromodomain helicase DNA binding protein 1
CHD1L	CHDL; CHD1L-PENDING; chromodomain helicase DNA binding protein 1-like
CHD2	chromodomain helicase DNA binding protein 2
CHD3	chromodomain helicase DNA binding protein 3; Mi-2a
CHD4	chromodomain helicase DNA binding protein 4; Mi-2b
CHDRL1	CHDRL1-PEN; chlordecone reductase-like 1
CHDRL2	CHDRL2-PEN; chlordecone reductase-like 2
CHDRL3	CHDRL3-PEN; chlordecone reductase-like 3
CHE2	cholinesterase (serum) 2
CHI3L1	chitinase 3-like 1; HCGP-3P; GP39; YKL40; YKL-40
CHI3L2	chitinase 3-like 2
CHIT1	"chitinase 1; chitinase, chitotriosidase; CHIT-LSB; Hs.79115; CHIT"
CHK	Hs.77221; CKI; choline kinase
CHKL	choline kinase-like
CHST1	carbohydrate (chondroitin 6/keratan) sulfotransferase 1; C6ST; KSGal6ST
CHST2	carbohydrate (chondroitin 6/keratan) sulfotransferase 2
CHST3	carbohydrate (chondroitin 6/keratan) sulfotransferase 3; C6ST; carbohydrate (chondroitin 6/keratan) sulfotransferase 3
CHST4	carbohydrate (N-acetylglucosamine 6-O) sulfotransferase 4; HEC-GLCNAC-6-ST; N-acetylglucosamine 6-O-sulfotransferase; LSST
CHUK	conserved helix-loop-helix ubiquitous kinase; IKK1; NFKBIKA; IkBKA; IKK-alpha; TCF16
CILP	"cartilage intermediate layer protein, nucleotide pyrophosphohydrolase"
CIT	"CRIK; STK21; KIAA0949; citron (rho-interacting, serine/theorine kinase 21)"
CKB	"Hs.669; CKBB; creatine kinase, brain"

Name	Description of Enzyme
CKBE	"creatine kinase, ectopic expression"
CKBP1	creatine kinase B pseudogene 1
CKM	"creatine kinase, muscle; Hs.75635; CKMM"
CKMT1	"CKMT; UMTCK; creatine kinase, mitochondrial 1 (ubiquitous)"
CKMT2	"Hs.80691; SMTCK; creatine kinase, mitochondrial 2 (sarcomeric)"
CKS1	CDC28 protein kinase 1; Hs.77550; CKS1(S. cerevisiae Cdc28/Cdc2 kinase subunit) homolog-1
CKS2	CDC28 protein kinase 2; Hs.83758; CKS1(S. cerevisiae Cdc28/Cdc2 kinase subunit) homolog-2
CLCN1	"CLC1; chloride channel 1, skeletal muscle (Thomsen disease, autosomal dominant)"
CLCN5	"NPHL2; chloride channel 5; Hs.3121; DENTS; nephrolithiasis 2 (X-linked, Dent disease)"
CLK1	CLK; CDC-like kinase
CLK2	CDC-like kinase 2
CLK2P	"CDC-like kinase 2, pseudogene"
CLK3	CDC-like kinase 3
CLN2	"ceroid-lipofuscinosis, neuronal 2, late infantile (Jansky-Bielschowsky disease)"
CLN3	"ceroid-lipofuscinosis, neuronal 3, juvenile (Batten, Spielmeyer-Vogt disease); Hs.77479; BTS"
CLN4	"ceroid-lipofuscinosis, neuronal 4 (Kufs disease)"
CLPP	"ClpP (caseinolytic protease, ATP-dependent, proteolytic subunit, E. coli) homolog"
CLPS	"Hs.1340; colipase, pancreatic"
CLPX	"ClpX (caseinolytic protease X, E. coli) homolog; energy-dependent regulator of proteolysis"
CMA1	"chymase 1, mast cell"
CMAH	cytidine monophosphate-N-acetylneuraminic acid hydroxylase (CMP-N-acetylneuraminate monooxygenase)
CMAS	CYTIDINE 5-PRIME-MONOPHOSPHATE N-ACETYLNEURAMINIC ACID SYNTHETASE
CNK	cytokine-inducible kinase; FNK; PRK
CNK1	KSR; connector enhancer of KSR-like (Drosophila kinase suppressor of ras)
CNP	"Hs.75062; 2',3'-cyclic nucleotide 3' phosphodiesterase"
CNSN	Carnosinemia (carnosinase)
COLQ	collagen-like tail subunit (single strand of homotrimer) of asymmetric acetylcholinesterase
COMT	Hs.89893; catechol-O-methyltransferase; Hs.78534
COX10	cytochrome c oxidase subunit X (heme A: farnesyltransferase); Hs.77513
COX11	cytochrome c oxidase subunit 11
COX11P	"cytochrome c oxidase subunit 11, pseudogene"
COX15	cytochrome c oxidase subunit 15
COX17	"COX17 (yeast) homolog, cytochrome c oxidase assembly protein; human homolog of yeast mitochondrial copper recruitment gene"
COX17P	"COX17 (yeast) homolog, cytochrome c oxidase assembly protein, pseudogene"
COX4	Hs.686; cytochrome c oxidase subunit IV
COX4P1	COX4L1; cytochrome c oxidase subunit IV pseudogene 1

Name	Description of Enzyme
COX5A	VA; COX; COX-VA; cytochrome c oxidase subunit Va
COX5AP1	cytochrome c oxidase subunit Va pseudogene 1
COX5B	Hs.1342; cytochrome c oxidase subunit Vb
COX5BL1	cytochrome c oxidase subunit Vb-like 1
COX5BL2	cytochrome c oxidase subunit Vb-like 2
COX5BL3	cytochrome c oxidase subunit Vb-like 3
COX5BL4	cytochrome c oxidase subunit Vb-like 4
COX5BL5	cytochrome c oxidase subunit Vb-like 5
COX5BL6	cytochrome c oxidase subunit Vb-like 6
COX5BL7	cytochrome c oxidase subunit Vb-like 7
COX6A1	COX6A; cytochrome c oxidase subunit VIa polypeptide 1
COX6A1P	cytochrome c oxidase subunit VIa polypeptide 1 pseudogene
COX6A2	cytochrome c oxidase subunit VIa polypeptide 2
COX6B	Hs.83379; cytochrome c oxidase subunit VIb
COX6BP1	cytochrome c oxidase subunit VIb pseudogene 1
COX6BP2	cytochrome c oxidase subunit VIb pseudogene 2
COX6BP3	cytochrome c oxidase subunit VIb pseudogene 3
COX6BP4	cytochrome c oxidase subunit VIb pseudogene 4
COX6C	Hs.74649; cytochrome c oxidase subunit VIc
COX6CP1	cytochrome c oxidase subunit VIc pseudogene 1
COX7A1	cytochrome c oxidase subunit VIIa polypeptide 1 (muscle); Hs.71883; COX7A
COX7A2	Hs.2321; cytochrome c oxidase subunit VIIa polypeptide 2 (liver)
COX7A3	cytochrome c oxidase subunit VIIa polypeptide 3 (liver)
COX7B	Hs.75752; cytochrome c oxidase subunit VIIb
COX7C	Hs.3462; cytochrome c oxidase subunit VIIc
COX7CP1	cytochrome c oxidase subunit VIIc pseudogene 1
COX7RP	cytochrome c oxidase subunit VII-related protein
COX8	cytochrome c oxidase subunit VIII
CP	Hs.10735; ceruloplasmin (ferroxidase)
CPA1	Hs.2879; CPA; carboxypeptidase A1 (pancreatic)
CPA2	carboxypeptidase A2 (pancreatic)
CPA3	Hs.646; carboxypeptidase A3 (mast cell)
CPB1	carboxypeptidase B1 (tissue); Hs.56117
CPB2	carboxypeptidase B2 (plasma); CPU; carboxypeptidase U; Hs.75572; PCPB
CPD	carboxypeptidase D
CPE	Hs.75360; carboxypeptidase E
CPM	Hs.50997; carboxypeptidase M
CPN1	"carboxypeptidase N, polypeptide 1, 50kD; CPNE1"
CPN2	"ACBP; carboxypeptidase N, polypeptide 2, 83kD; Hs.2246; arginine carboxypeptidase (carboxypeptidase N)"
CPO	"Hs.89866; CPX; coproporphyrinogen oxidase (coproporphyria, harderoporphyria); Hs.79904"
CPP	ceruloplasmin (ferroxidase) pseudogene
CPS1	"Hs.50966; carbamoyl-phosphate synthetase 1, mitochondrial"
CPT1A	"CPT1; carnitine palmitoyltransferase I, liver; CPT1-L; L-CPT1"

Name	Description of Enzyme
CPT1B	"carnitine palmitoyltransferase I, muscle; M-CPT1; CPT1-M"
CPT2	1; CPT1; CPTASE; carnitine palmitoyltransferase II
CPZ	carboxypeptidase Z
CRAT	Hs.12068; CAT1; carnitine acetyltransferase
CRMP1	collapsin response mediator protein 1 (dihydropyrimidinase-like 1); DRP-1; DPYSL1; Hs.75079
CRY1	PHLL1; cryptochrome 1 (photolyase-like)
CRY2	cryptochrome 2 (photolyase-like)
CRYZ	"Hs.83114; crystallin, zeta (quinone reductase)"
CRYZL1	"crystallin, zeta (quinone reductase)-like 1"
CRYZP1	"crystallin, zeta (quinone reductase) pseudogene 1"
CS	citrate synthase
CSCI	Corticosterone side-chain isomerase
CSK	Hs.89756; c-src tyrosine kinase; Hs.77793
CSN1	"casein, alpha; Hs.3155; CASA"
CSN10	"casein, kappa; CSN3"
CSN2	"casein, beta; Hs.2242; CASB"
CSNK1A1	"Hs.52195; casein kinase 1, alpha 1"
CSNK1D	"casein kinase 1, delta; Hs.75852; HCKID"
CSNK1E	"casein kinase 1, epsilon; Hs.79658; CKIe; HCKIE"
CSNK1G2	"casein kinase 1, gamma 2"
CSNK1G3	"casein kinase 1, gamma 3"
CSNK2A1	"Hs.12740; casein kinase 2, alpha 1 polypeptide"
CSNK2A1P	"casein kinase 2, alpha 1 polypeptide pseudogene"
CSNK2A2	"Hs.82201; CSNK2A1; casein kinase 2, alpha prime polypeptide"
CSNK2B	"Hs.84316; casein kinase 2, beta polypeptide"
CST	cerebroside (3'-phosphoadenylylsulfate:galactosylceramide 3') sulfotransferase
CTBS	"CTB; chitobiase, di-N-acetyl-; Hs.99889"
CTD	Coats disease
CTDP1	"CTD (carboxy-terminal domain, RNA polymerase II, polypeptide A) phosphatase, subunit 1; FCP1; CTD (carboxy-terminal domain, RNA polymerase II, polypeptide A) phosphatase, subunit 1"
CTH	Hs.19904; cystathionase (cystathionine gamma-lyase)
CTPS	Hs.84112; CTP synthase
CTRC	"chymotrypsin C (caldecrin); caldecrin (serum calcium decreasing factor, elastase IV); CLCR"
CTSD	Hs.79572; CPSD; cathepsin D (lysosomal aspartyl protease)
CYBB	"cytochrome b-245, beta polypeptide (chronic granulomatous disease); Hs.88974; CGD; GP91-PHOX"
CYP11B1	"cytochrome P450, subfamily XIB (steroid 11-beta-hydroxylase), polypeptide 1; Hs.2610; CYP11B"
CYP11B2	"cytochrome P450, subfamily XIB (steroid 11-beta-hydroxylase), polypeptide 2; Hs.36986; CYP11B"
CYP17	"Hs.1363; cytochrome P450, subfamily XVII (steroid 17-alpha-hydroxylase), adrenal hyperplasia"

Name	Description of Enzyme
CYP19	"cytochrome P450, subfamily XIX (aromatization of androgens); Hs.79946; aromatase"
CYP21A1P	"CYP21P; cytochrome P450, subfamily XXIA (steroid 21-hydroxylase), polypeptide 1 pseudogene; CYP21A; cytochrome P450, subfamily XXI (steroid 21-hydroxylase) pseudogene; P450c21A"
CYP21A2	"CYP21; cytochrome P450, subfamily XXIA (steroid 21-hydroxylase, congenital adrenal hyperplasia), polypeptide 2; Hs.49066; CYP21B; cytochrome P450, subfamily XXI (steroid 21-hydroxylase, congenital adrenal hyperplasia); P450c21B"
CYP24	"cytochrome P450, subfamily XXIV (vitamin D 24-hydroxylase)"
CYP27A1	"CYP27; cytochrome P450, subfamily XXVIIA (steroid 27-hydroxylase, cerebrotendinous xanthomatosis), polypeptide 1; Hs.82568; cytochrome P450, subfamily XXVII (sterol 27-hydroxylase, cerebrotendinous xanthomatosis)"
CYP27B1	"PDDR; cytochrome P450, subfamily XXVIIB (25-hydroxyvitamin D-1-alpha-hydroxylase), polypeptide 1; VDR; VDD1; pseudo-vitamin D dependency rickets 1; CYP1; P450c1; VDDR I"
CYP2C	"Hs.703; cytochrome P450, subfamily IIC (mephenytoin 4-hydroxylase)"
CYP2C10	"cytochrome P450, subfamily IIC (mephenytoin 4-hydroxylase), polypeptide 10"
CYP2C18	"CYP2C17; cytochrome P450, subfamily IIC (mephenytoin 4-hydroxylase), polypeptide 18; Hs.702; P450IIC17; cytochrome P450, subfamily IIC (mephenytoin 4-hydroxylase), polypeptide 17"
CYP2C19	"cytochrome P450, subfamily IIC (mephenytoin 4-hydroxylase), polypeptide 19; P450IIC19"
CYP2C8	"cytochrome P450, subfamily IIC (mephenytoin 4-hydroxylase), polypeptide 8"
CYP2C9	"cytochrome P450, subfamily IIC (mephenytoin 4-hydroxylase), polypeptide 9; Hs.9669; P450IIC9"
CYP2J2	"cytochrome P450, subfamily IIJ (arachidonic acid epoxygenase), polypeptide 2; Hs.30894"
CYP3A	"CYP3; cytochrome P450, subfamily IIIA (niphedipine oxidase)"
CYP3A3	"Hs.73725; cytochrome P450, subfamily IIIA (niphedipine oxidase), polypeptide 3"
CYP3A4	"cytochrome P450, subfamily IIIA (niphedipine oxidase), polypeptide 4; Hs.45"
CYP3A5	"cytochrome P450, subfamily IIIA (niphedipine oxidase), polypeptide 5; Hs.146"
CYP3A5P1	"cytochrome P450, subfamily IIIA (niphedipine oxidase), pseudogene 1"
CYP46	"cytochrome P450, subfamily 46 (cholesterol 24-hydroxylase)"
CYP4F3	"LTB4H; cytochrome P450, subfamily IVF, polypeptide 3 (leukotriene B4 omega hydroxylase); leukotriene B4 omega hydroxylase (cytochrome P450, subfamily IVF); Hs.101; CYP4F"
CYP51	"cytochrome P450, 51 (lanosterol 14-alpha-demethylase); Hs.2379"
CYP7A1	"CYP7; cytochrome P450, subfamily VIIA (cholesterol 7 alpha-monooxygenase), polypeptide 1; Hs.1644; cholesterol 7-alpha-hydroxylase"
CYP7B1	"cytochrome P450, subfamily VIIB (oxysterol 7 alpha-hydroxylase), polypeptide 1"
CYP8B1	"cytochrome P450, subfamily VIIIB (sterol 12-alpha-hydroxylase), polypeptide 1; CYP12"
DAO	Hs.2625; DAMOX; D-amino-acid oxidase
DAPK1	DAPK; death-associated protein kinase 1

Name	Description of Enzyme
DAPK3	death-associated protein kinase 3
DBH	Hs.2301; dopamine beta-hydroxylase (dopamine beta-monooxygenase)
DBT	Hs.89685; dihydrolipoamide branched chain transacylase (E2 component of branched chain keto acid dehydrogenase complex; maple syrup urine disease); Hs.23443; Hs.89479
DCI	"Hs.89466; dodecenoyl-Coenzyme A delta isomerase (3,2 trans-enoyl-Coenzyme A isomerase)"
DCK	Hs.709; deoxycytidine kinase
DCT	"Hs.23454; TYRP2; dopachrome tautomerase (dopachrome delta-isomerase, tyrosine-related protein 2); Hs.472"
DCTD	Hs.76894; dCMP deaminase
DDAH1	dimethylarginine dimethylaminohydrolase 1; DDAH; DDAHI
DDAH2	dimethylarginine dimethylaminohydrolase 2; DDAHII
DDC	Hs.475; dopa decarboxylase (aromatic L-amino acid decarboxylase)
DDO	D-aspartate oxidase
DDOST	dolichyl-diphosphooligosaccharide-protein glycosyltransferase; OST
DDR1	"NEP; CAK; EDDR1; NTRK4; PTK3A; PTK3A protein tyrosine kinase 3A; neurotrophic tyrosine kinase, receptor, type 4; Hs.75562; neuroepithelial tyrosine kinase; cell adhesion kinase; trkE; RTK6; epithelial discoidin domain receptor 1"
DDR2	"NTRKR3; TKT; TYRO10; neurotrophic tyrosine kinase, receptor-related 3"
DDT	D-dopachrome tautomerase
DDX10	DEAD/H (Asp-Glu-Ala-Asp/His) box polypeptide 10 (RNA helicase); HRH-J8
DDX11	DEAD/H (Asp-Glu-Ala-Asp/His) box polypeptide 11 (S.cerevisiae CHL1-like helicase); CHLR1
DDX12	DEAD/H (Asp-Glu-Ala-Asp/His) box polypeptide 12 (S.cerevisiae CHL1-like helicase); CHLR2
DDX5	"HLR1; G17P1; DEAD/H (Asp-Glu-Ala-Asp/His) box polypeptide 5 (RNA helicase, 68kD)"
DDX6	"RCK; HLR2; DEAD/H (Asp-Glu-Ala-Asp/His) box polypeptide 6 (RNA helicase, 54kD)"
DDX7	"DEAD/H (Asp-Glu-Ala-Asp/His) box polypeptide 7 (RNA helicase, 52kD) NOTE: Symbol and name provisional"
DDX8	DEAD/H (Asp-Glu-Ala-Asp/His) box polypeptide 8 (RNA helicase); HRH1
DDX9	"DEAD/H (Asp-Glu-Ala-Asp/His) box polypeptide 9 (RNA helicase A, nuclear DNA helicase II); NDHII"
DDX9P	DEAD/H (Asp-Glu-Ala-Asp/His) box polypeptide 9 (RNA helicase A) pseudogene
DDXL	"nuclear RNA helicase, DECD variant of DEAD box family"
DECR	"2,4-dienoyl CoA reductase"
DFFB	"DNA fragmentation factor, 40 kD, beta polypeptide (caspase-activated DNase); DNA fragmentation factor, 40 kD, beta subunit; CAD; DFF2; CPAN; DFF40; DFF-40"
DGAT	diacylglycerol O-acyltransferase (mouse) homolog; ARGP1
DGKA	"DAGK1; diacylglycerol kinase, alpha (80kD); Hs.74044; DGK-alpha; DAGK"
DGKB	"DAGK2; diacylglycerol kinase, beta (90kD); KIAA0718"
DGKD	"diacylglycerol kinase, delta (130kD); DAGK4-PEN; KIAA0145; DGKdelta"
DGKE	"diacylglycerol kinase, epsilon (64kD); DAGK6; DAGK6-PEN"

Name	Description of Enzyme
DGKG	"DAGK3; diacylglycerol kinase, gamma (90kD); Hs.89462"
DGKH	"DGKETA; diacylglycerol kinase, eta"
DGKI	"diacylglycerol kinase, iota"
DGKQ	"DAGK4; diacylglycerol kinase, theta (110kD); diacylglycerol kinase, delta (110kD); Hs.89979; DAGK; DAGK7"
DGKZ	"diacylglycerol kinase, zeta (104kD); DAGK5; DAGK5-PEN; hDGKzeta"
DGUOK	deoxyguanosine kinase; Hs.101519; dGK; Hs.77494
DHCR24	24-dehydrocholesterol reductase
DHCR7	7-dehydrocholesterol reductase
DHFR	Hs.83765; dihydrofolate reductase
DHFRP1	Hs.73878; dihydrofolate reductase pseudogene 1
DHFRP2	dihydrofolate reductase pseudogene 2
DHFRP4	dihydrofolate reductase pseudogene 4
DHODH	Hs.1151; dihydroorotate dehydrogenase
DHPS	deoxyhypusine synthase; Hs.79064
DIA1	diaphorase (NADH) (cytochrome b-5 reductase)
DIA2	Diaphorase-2
DIA4	"NMOR1; diaphorase (NADH/NADPH) (cytochrome b-5 reductase); NMORI; diaphorase (NADH/NADPH); NAD(P)H menadione oxidoreductase 1, dioxin-inducible"
DIFF6	differentiation 6 (deoxyguanosine triphosphate triphosphohydrolase; KIAA0158
DIO1	"TXDI1; deiodinase, iodothyronine, type I; 5DI; thyroxine deiodinase type I (selenoprotein)"
DIO2	"deiodinase, iodothyronine type II; thyroxine deiodinase type II; TXDI2"
DIO3	"TXDI3; deiodinase, iodothyronine type III; thyroxine deiodinase type III (selenoprotein)"
DLAT	Hs.74642; DLTA; PDC-E2; dihydrolipoamide S-acetyltransferase (E2 component of pyruvate dehydrogenase complex)
DLD	"Hs.74635; LAD; DLDH; dihydrolipoamide dehydrogenase (E3 component of pyruvate dehydrogenase complex, 2-oxo-glutarate complex, branched chain keto acid dehydrogenase complex)"
DLST	Hs.401; DLTS; dihydrolipoamide S-succinyltransferase (E2 component of 2-oxo-glutarate complex)
DLSTP	dihydrolipoamide S-succinyltransferase pseudogene (E2 component of 2-oxo-glutarate complex)
DMPK	DM; DM1; dystrophia myotonica-protein kinase; dystrophia myotonica 1 (includes dystrophia myotonia protein kinase); Hs.898
DNA2L	"DNA2 (DNA replication helicase, yeast, homolog)-like"
DNASE1	DNL1; deoxyribonuclease I
DNASE1L1	DNL1L; deoxyribonuclease I-like 1
DNASE1L2	deoxyribonuclease I-like 2
DNASE1L3	deoxyribonuclease I-like 3
DNASE2	"DNL2; deoxyribonuclease II, lysosomal; DNL; DNase II, lysosomal"
DNMT1	DNMT; DNA (cytosine-5-)-methyltransferase 1; Hs.77462; DNA methyltransferase
DNMT2	DNA (cytosine-5-)-methyltransferase 2
DNMT3A	DNA (cytosine-5-)-methyltransferase 3 alpha

Name	Description of Enzyme
DNMT3B	DNA (cytosine-5-)-methyltransferase 3 beta
DNPEP	aspartyl aminopeptidase; DAP
DNTT	"TDT; deoxynucleotidyltransferase, terminal"
DOK1	docking protein 1 (downstream of tyrosine kinase 1); p62dok
DPAGT1	DPAGT; DPAGT2; dolichyl-phosphate alpha-N-acetylglucosaminyltransferase 1; dolichyl-phosphate N-acetylglucosaminephosphotransferase 2 (GlcNAc-1-P transferase); UGAT; dolichyl-phosphate alpha-N-acetylglucosaminyltransferase
DPEP1	Hs.109; dipeptidase 1 (renal)
DPM1	"dolichyl-phosphate mannosyltransferase polypeptide 1, catalytic subunit"
DPM2	"dolichyl-phosphate mannosyltransferase polypeptide 2, regulatory subunit"
DPP3	dipeptidylpeptidase III
DPP4	"Hs.44926; CD26; ADCP2; dipeptidylpeptidase IV (CD26, adenosine deaminase complexing protein 2)"
DPP6	Hs.34074; DPPX; dipeptidylpeptidase VI
DPYD	dihydropyrimidine dehydrogenase
DPYS	dihydropyrimidinase; DHPase
DPYSL2	dihydropyrimidinase-like 2; DHPRP2; DRP-2; CRMP2
DPYSL3	dihydropyrimidinase-like 3; DRP-3
DPYSL4	ULIP4; dihydropyrimidinase-like 4
DTYMK	Hs.79006; deoxythymidylate kinase
DUSP1	HVH1; CL100; PTPN10; dual specificity phosphatase 1; MKP-1
DUSP11	PIR1; dual specificity phosphatase 11 (RNA/RNP complex 1-interacting)
DUSP2	PAC-1; dual specificity phosphatase 2
DUSP3	VHR; dual specificity phosphatase 3 (vaccinia virus phosphatase VH1-related)
DUSP4	HVH2; dual specificity phosphatase 4; MKP-2
DUSP5	HVH3; dual specificity phosphatase 5
DUSP6	dual specificity phosphatase 6; MKP-3; PYST1
DUSP7	dual specificity phosphatase 7; MKP-X; PYST2
DUSP8	dual specificity phosphatase 8; HVH-5; HB5
DUSP8P	dual specificity phosphatase 8 pseudogene
DUSP9	dual specificity phosphatase 9; MKP4; MKP-4
DUSPP	dual specificity phosphatase pseudogene; HVH4
DUT	dUTP pyrophosphatase; Hs.82113
DYRK1A	DYRK; DYRK1; MNBH; dual-specificity tyrosine-(Y)-phosphorylation regulated kinase; MNB; minibrain (Drosophila) homolog; Hs.103125
DYRK1B	dual-specificity tyrosine-(Y)-phosphorylation regulated kinase 1B
DYRK2	dual-specificity tyrosine-(Y)-phosphorylation regulated kinase 2
DYRK3	dual-specificity tyrosine-(Y)-phosphorylation regulated kinase 3
DYRK4	dual-specificity tyrosine-(Y)-phosphorylation regulated kinase 4
EBP	CDPX2; emopamil-binding protein (sterol isomerase); phenylalkylamine Ca2+ antagonist (emopamil) binding protein; chondrodysplasia punctata 2 (X-linked dominant); CPX; CPXD
ECH1	"enoyl Coenzyme A hydratase 1, peroxisomal"
ECHS1	"enoyl Coenzyme A hydratase, short chain, 1, mitochondrial; SCEH"
EFNA1	"EPLG1; ephrin-A1; LERK1; ECKLG; TNFAIP4; eph-related receptor tyrosine kinase ligand 1 (tumor necrosis factor, alpha-induced protein 4); B61"

Name	Description of Enzyme
EFNA2	EPLG6; ephrin-A2; ELF-1; LERK6; eph-related receptor tyrosine kinase ligand 6
EFNA3	EPLG3; ephrin-A3; LERK3; eph-related receptor tyrosine kinase ligand 3; Ehk1-L
EFNA4	EPLG4; ephrin-A4; LERK4; eph-related receptor tyrosine kinase ligand 4
EFNA5	EPLG7; ephrin-A5; Hs.37142; AF1; LERK7; eph-related receptor tyrosine kinase ligand 7
EFNB1	EPLG2; ephrin-B1; LERK2; eph-related receptor tyrosine kinase ligand 2; Elk-L
EFNB2	EPLG5; ephrin-B2; Hs.30942; LERK5; eph-related receptor tyrosine kinase ligand 5; Htk-L
EFNB3	EPLG8; ephrin-B3; eph-related receptor tyrosine kinase ligand 8; Hs.26988; LERK-8
EHHADH	Hs.1531; enoyl-Coenzyme A hydratase/3-hydroxyacyl Coenzyme A dehydrogenase
EIF2AK3	eukaryotic translation initiation factor 2-alpha kinase 3; PEK; WRS; PERK; Wolcott-Rallison syndrome
ELA1	"Hs.21; elastase 1, pancreatic"
ELA2	"SERP1; elastase 2, neutrophil; Hs.99863; serine protease"
ELA3	"elastase 3, pancreatic (protease E)"
ELA3B	elastase 3B
ELANH2	"EI; PI2; protease inhibitor 2 (anti-elastase), monocyte/neutrophil derived"
ELL2	"ELL-RELATED RNA POLYMERASE II, ELONGATION FACTOR"
EMK1	ELKL motif kinase 1; MARK2
ENDOG	endonuclease G
ENDOGL1	ENGL; endonuclease G-like 1
ENDOGL2	ENGL-B; endonuclease G-like 2
ENO1	"ENO1L1; enolase 1, (alpha)-like 1; Hs.675; enolase 1, (alpha); PPH; phosphopyruvate hydratase"
ENO1P	"enolase 1, (alpha) pseudogene"
ENO2	"Hs.75675; enolase 2, (gamma, neuronal)"
ENO3	"enolase 3, (beta, muscle); Hs.99986; ENO-3; Hs.2645"
ENPEP	glutamyl aminopeptidase (aminopeptidase A); Hs.291; gp160
EPHA1	EPHT1; EphA1; EPH; EPHT; eph tyrosine kinase 1 (erythropoietin-producing hepatoma amplified sequence); ephrin receptor EphA1
EPHA2	ECK; EphA2; ephrin receptor EphA2; epithelial cell receptor protein tyrosine kinase
EPHA3	ETK1; EphA3; ETK; HEK; eph-like tyrosine kinase 1 (human embryo kinase 1); ephrin receptor EphA3
EPHA4	TYRO1; EphA4; TYRO1 protein tyrosine kinase; Hek8; ephrin receptor EphA4
EPHA8	"EEK; EphA8; eph-, elk-related tyrosine kinase; Hek3; ephrin receptor EphA8"
EPHB1	EPHT2; EphB1; eph tyrosine kinase 2; Elk; Hek6; ephrin receptor EphB1
EPHB2	DRT; ERK; EPHT3; EphB2; eph tyrosine kinase 3; developmentally-regulated eph-related tyrosine kinase; Hek5; Tyro5; EPHT3; ephrin receptor EphB2; elk-related tyrosine kinase
EPHB3	ETK2; EphB3; HEK2; eph-like tyrosine kinase 2 (human embryo kinase 2); Hek2; Tyro6; ephrin receptor EphB3

Name	Description of Enzyme
EPHB4	HTK; EphB4; Hs.464; hepatoma transmembrane kinase; Tyro11; ephrin receptor EphB4
EPHX1	"epoxide hydrolase 1, microsomal (xenobiotic); Hs.89689; EPHX; Hs.89649"
EPHX2	"Hs.113; epoxide hydrolase 2, cytoplasmic"
EPM2A	"epilepsy, progressive myoclonus type 2, Lafora disease (laforin); EPM2; MELF"
EPR1	effector cell protease receptor 1; EPR-1; effector cell protease receptor 1
EPRS	QARS; QPRS; glutamyl-prolyl-tRNA synthetase
EPX	eosinophil peroxidase; EPX-PEN; EPO; EPP
ERP70	"ERP72; protein disulfide isomerase related protein (calcium-binding protein, intestinal-related)"
ESA4	esterase A4
ESAT	esterase activator
ESB3	esterase B3
ESD	Hs.82193; esterase D/formylglutathione hydrolase
ETFDH	ETFQO; electron-transferring-flavoprotein dehydrogenase
EXO1	HEX1; exonuclease 1
EYA1	BOR; eyes absent (Drosophila) homolog 1; branchiootorenal syndrome; Melnick-Fraser syndrome
F2R	coagulation factor II (thrombin) receptor; TR; CF2R; PAR1; Hs.85889; protease-activated receptor 1
F9	"coagulation factor IX (plasma thromboplastic component, Christmas disease, hemophilia B); Hs.1330; FIX; Factor 9; Factor IX"
FAAH	fatty acid amide hydrolase
FACL1	"fatty-acid-Coenzyme A ligase, long-chain 1; Hs.89549; Hs.34"
FACL2	"FACL1; fatty-acid-Coenzyme A ligase, long-chain 2"
FACL3	"fatty-acid-Coenzyme A ligase, long-chain 3; ACS3"
FACL4	"fatty-acid-Coenzyme A ligase, long-chain 4"
FACVL1	"VLCS; VLACS; fatty-acid-Coenzyme A ligase, very long-chain 1"
FADS1	LLCDL1; linoleoyl-CoA desaturase (delta-6-desaturase)-like 1
FADS2	LLCDL2; linoleoyl-CoA desaturase (delta-6-desaturase)-like 2
FADS3	LLCDL3; linoleoyl-CoA desaturase (delta-6-desaturase)-like 3
FADSD6	delta-6 fatty acid desaturase
FAH	Hs.73875; fumarylacetoacetase; fumarylacetoacetate
FAK2	"focal adhesion kinase 2; cell adhesion kinase, beta; PKB; PYK2; RAFTK; CAK beta; proline-rich tyrosine kinase 2; CAKB"
FARS1	phenylalanine-tRNA synthetase
FARSL	phenylalanine-tRNA synthetase-like; CML33
FASN	fatty acid synthase
FASTK	Fas-activated serine/threonine kinase
FBP1	Hs.574; FBP; fructose-bisphosphatase 1
FBP2	"fructose-1,6-bisphosphatase 2"
FDFT1	farnesyl-diphosphate farnesyltransferase 1; Squalene synthase
FDH	formaldehyde dehydrogenase
FDPS	"Hs.99926; farnesyl diphosphate synthase (farnesyl pyrophosphate synthetase, dimethylallyltranstransferase, geranyltranstransferase); Hs.123; Hs.99866"

Name	Description of Enzyme
FDPSL1	"FPSL1; CHR39A; farnesyl diphosphate synthase-like 1 (farnesyl pyrophosphate synthetase-like 1, cholesterol-repressible protein 39A)"
FDPSL2	FPSL2; farnesyl diphosphate synthase-like 2 (farnesyl pyrophosphate synthetase-like 2)
FDPSL3	FPSL3; farnesyl diphosphate synthase-like 3 (farnesyl pyrophosphate synthetase-like 3)
FDPSL4	FPSL4; farnesyl diphosphate synthase-like 4 (farnesyl pyrophosphate synthetase-like 4)
FDPSL5	FPSL5; farnesyl diphosphate synthase-like 5 (farnesyl pyrophosphate synthetase-like 5)
FDXR	Hs.69745; ADXR; ferredoxin reductase
FECH	ferrochelatase (protoporphyria); Hs.26
FECHP	ferrochelatase pseudogene
FEN1	RAD2; flap structure-specific endonuclease 1; FEN-1; RAD2 (S. pombe) homolog
FENL1	flap endonuclease-like 1
FER	fer (fps/fes related) tyrosine kinase (phosphoprotein NCP94); TYK3
FGFR1	"fibroblast growth factor receptor 1 (fms-related tyrosine kinase 2, Pfeiffer syndrome); Hs.99988; H2; H3; H4; H5; CEK; FLG; FLT2; BFGFR; N-SAM; Hs.748"
FGFR2	"fibroblast growth factor receptor 2 (bacteria-expressed kinase, keratinocyte growth factor receptor, craniofacial dysostosis 1, Crouzon syndrome, Pfeiffer syndrome, Jackson-Weiss syndrome); Hs.82775; BEK; JWS; CEK3; KGFR; TK14; TK25; ECT1; CFD1; K-SAM"
FH	Hs.75653; fumarate hydratase
FIC1	"BRIC; PFIC1; PFIC; benign recurrent intrahepatic cholestasis; progressive familial intrahepatic cholestasis 1, Byler disease; familial intrahepatic cholestasis 1"
FLR	flavin reductase (NADPH)
FLT1	Hs.96085; FLT; fms-related tyrosine kinase 1 (vascular endothelial growth factor/vascular permeability factor receptor)
FLT3	STK1; fms-related tyrosine kinase 3
FLT3LG	Hs.428; fms-related tyrosine kinase 3 ligand
FLT4	fms-related tyrosine kinase 4; Hs.74049; VEGFR3
FMO1	Hs.1424; flavin containing monooxygenase 1
FMO2	Hs.80876; flavin containing monooxygenase 2
FMO3	FMOII; flavin containing monooxygenase 3
FMO4	Hs.89763; FMO2; flavin containing monooxygenase 4
FMO5	Hs.14286; flavin containing monooxygenase 5
FNTA	"farnesyltransferase, CAAX box, alpha; FPTA; PGGT1A; Hs.78630"
FNTAL1	"farnesyltransferase, CAAX box, alpha-like 1"
FNTAL2	"farnesyltransferase, CAAX box, alpha-like 2"
FNTB	"farnesyltransferase, CAAX box, beta; FPTB; Hs.276"
FNTBL1	"farnesyltransferase, CAAX box, beta-like 1"
FOLH1	FOLH; folate hydrolase 1 (prostate-specific membrane antigen); PSM
FOLH2	FOLHP; folate hydrolase 2; folate hydrolase pseudogene
FPGS	folylpolyglutamate synthase

Name	Description of Enzyme
FPGT	GFPP; fucose-1-phosphate guanylyltransferase
FRK	Hs.89426; fyn-related kinase
FTCD	formiminotransferase cyclodeaminase
FTHFD	formyltetrahydrofolate dehydrogenase
FUCA1	"fucosidase, alpha-L- 1, tissue; Hs.576; FUCA"
FUCA1P	"fucosidase, alpha-L- 1, tissue pseudogene"
FUCA2	"fucosidase, alpha-L- 2, plasma"
FUT1	"Hs.69747; H; fucosyltransferase 1 (alpha (1,2) fucosyltransferase, Bombay phenotype included)"
FUT2	fucosyltransferase 2 (secretor status included); SE
FUT3	"Hs.92753; LE; fucosyltransferase 3 (galactoside 3(4)-L-fucosyltransferase, Lewis blood group included); Hs.2527; Hs.89742; Hs.92752"
FUT4	"Hs.2173; CD15; FCT3A; FUC-TIV; fucosyltransferase 4 (alpha (1,3) fucosyltransferase, myeloid-specific)"
FUT5	"Hs.32955; FUC-TV; fucosyltransferase 5 (alpha (1,3) fucosyltransferase)"
FUT6	"fucosyltransferase 6 (alpha (1,3) fucosyltransferase)"
FUT7	"fucosyltransferase 7 (alpha (1,3) fucosyltransferase)"
FUT8	"fucosyltransferase 8 (alpha (1,6) fucosyltransferase)"
FUT9	"fucosyltransferase 9 (alpha (1,3) fucosyltransferase); FUC-TIX"
G3BP	Ras-GTPase-activating protein SH3-domain-binding protein
G6PC	"G6PT; glucose-6-phosphatase, catalytic (glycogen storage disease type I, von Gierke disease); Hs.242; GSD1a"
G6PD	glucose-6-phosphate dehydrogenase; Hs.80206; G6PD1; Hs.1435
G6PDL	glucose-6-phosphate dehydrogenase-like
G6PR	"glucose-6-phosphatase, regulatory; GSD1aSP"
G6PT1	"glucose-6-phosphatase, transport (glucose-6-phosphate) protein 1; GSD1b"
G6PT2	"glucose-6-phosphatase, transport (phosphate/pyrophosphate) protein 2; GSD1c"
G6PT3	"glucose-6-phosphatase, transport (glucose) protein 3; GSD1d"
G7P1	kinase-like protein
GAA	"Hs.1437; glucosidase, alpha; acid (Pompe disease, glycogen storage disease type II)"
GAD1	"Hs.75668; GAD; glutamate decarboxylase 1 (brain, 67kD)"
GAD2	"Hs.89662; glutamate decarboxylase 2 (pancreatic islets and brain, 65kD); Hs.1668"
GAD3	glutamate decarboxylase 3
GAK	cyclin G associated kinase
GALC	galactosylceramidase (Krabbe disease); Hs.273
GALE	"galactose-4-epimerase, UDP-"
GALGT	"UDP-N-acetyl-alpha-D-galactosamine:(N-acetylneuraminyl)-galactosylglucosylceramide N-acetylgalactosaminyltransferase (GalNAc-T); beta1,4GalNAc-T"
GALK1	GALK; galactokinase 1
GALK2	Hs.99935; GK2; galactokinase 2
GALNS	"GAS; GALNAC6S; galactosamine (N-acetyl)-6-sulfate sulfatase (Morquio syndrome, mucopolysaccharidosis type IVA)"

Name	Description of Enzyme
GALNT1	UDP-N-acetyl-alpha-D-galactosamine:polypeptide N-acetylgalactosaminyltransferase 1 (GalNAc-T1)
GALNT2	UDP-N-acetyl-alpha-D-galactosamine:polypeptide N-acetylgalactosaminyltransferase 2 (GalNAc-T2)
GALNT3	UDP-N-acetyl-alpha-D-galactosamine:polypeptide N-acetylgalactosaminyltransferase 3 (GalNAc-T3)
GALNT4	GALNAC-T4; UDP-N-acetyl-alpha-D-galactosamine:polypeptide N-acetylgalactosaminyltransferase 4 (GalNAc-T4)
GALNT5	GALNAC-T5; UDP-N-acetyl-alpha-D-galactosamine:polypeptide N-acetylgalactosaminyltransferase 5 (GalNAc-T5)
GALNT6	GALNAC-T6; UDP-N-acetyl-alpha-D-galactosamine:polypeptide N-acetylgalactosaminyltransferase 6 (GalNAc-T6)
GALNT7	UDP-N-acetyl-alpha-D-galactosamine:polypeptide N-acetylgalactosaminyltransferase 7 (GalNAc-T7)
GALT	Hs.75641; galactose-1-phosphate uridylyltransferase; Hs.56311
GAMT	guanidinoacetate N-methyltransferase
GANAB	"glucosidase, alpha; neutral AB"
GANC	"glucosidase, alpha; neutral C"
GAPD	Hs.74456; glyceraldehyde-3-phosphate dehydrogenase; GAPDH; G3PDH
GAPDL1	glyceraldehyde-3-phosphate dehydrogenase-like 1
GAPDL10	glyceraldehyde-3-phosphate dehydrogenase-like 10
GAPDL11	glyceraldehyde-3-phosphate dehydrogenase-like 11
GAPDL12	glyceraldehyde-3-phosphate dehydrogenase-like 12
GAPDL13	glyceraldehyde-3-phosphate dehydrogenase-like 13
GAPDL14	glyceraldehyde-3-phosphate dehydrogenase-like 14
GAPDL15	glyceraldehyde-3-phosphate dehydrogenase-like 15
GAPDL16	glyceraldehyde-3-phosphate dehydrogenase-like 16
GAPDL17	glyceraldehyde-3-phosphate dehydrogenase-like 17
GAPDL2	glyceraldehyde-3-phosphate dehydrogenase-like 2
GAPDL3	glyceraldehyde-3-phosphate dehydrogenase-like 3
GAPDL4	glyceraldehyde-3-phosphate dehydrogenase-like 4
GAPDL5	glyceraldehyde-3-phosphate dehydrogenase-like 5
GAPDL6	glyceraldehyde-3-phosphate dehydrogenase-like 6
GAPDL7	glyceraldehyde-3-phosphate dehydrogenase-like 7
GAPDL8	glyceraldehyde-3-phosphate dehydrogenase-like 8
GAPDL9	glyceraldehyde-3-phosphate dehydrogenase-like 9
GAPDP1	glyceraldehyde-3-phosphate dehydrogenase pseudogene 1
GAPDP14	glyceraldehyde-3-phosphate dehydrogenase pseudogene 14
GAPL	GTPase activating protein-like
GARS	Hs.75280; GlyRS; glycyl-tRNA synthetase
GART	"phosphoribosylglycinamide formyltransferase, phosphoribosylglycinamide synthetase, phosphoribosylaminoimidazole synthetase; Hs.82285; PGFT; PRGS"
GAT	putative glycine-N-acyltransferase
GATM	glycine amidinotransferase (L-arginine:glycine amidinotransferase)
GBA	"glucosidase, beta; acid (includes glucosylceramidase); Hs.80377; GLUC"

Name	Description of Enzyme
GBAP	"glucosidase, beta; acid, pseudogene"
GBE1	"Hs.1691; glucan (1,4-alpha-), branching enzyme 1 (glycogen branching enzyme, Andersen disease, glycogen storage disease type IV)"
GCAT	glycine C-acetyltransferase (2-amino-3-ketobutyrate coenzyme A ligase); KBL
GCDH	Hs.63773; glutaryl-Coenzyme A dehydrogenase
GCH1	GTP cyclohydrolase 1 (dopa-responsive dystonia); Hs.103987; GCH; DYT5; GTPCH1; Hs.86724
GCHFR	GTP cyclohydrolase I feedback regulatory protein; p35; GFRP
GCK	"glucokinase (hexokinase 4, maturity onset diabetes of the young 2); Hs.1270; GK; GLK; HK4; NIDDM; MODY2"
GCKR	Hs.89771; glucokinase (hexokinase 4) regulatory protein
GCLC	"GLCLC; glutamate-cysteine ligase, catalytic subunit; Hs.1673; GCS; GLCL; glutamate-cysteine ligase (gamma-glutamylcysteine synthetase), catalytic (72.8kD)"
GCLM	"GLCLR; glutamate-cysteine ligase, modifier subunit; Hs.89709; glutamate-cysteine ligase (gamma-glutamylcysteine synthetase), regulatory (30.8kD)"
GCNT1	"Hs.781; C2GNT; NAGCT2; NACGT2; glucosaminyl (N-acetyl) transferase 1, core 2 (beta-1,6-N-acetylglucosaminyltransferase); C2GnTL; C2GnT-L"
GCNT2	"Hs.934; IGNT; NAGCT1; NACGT1; glucosaminyl (N-acetyl) transferase 2, I-branching enzyme"
GCNT3	"glucosaminyl (N-acetyl) transferase 3, mucin type; C2GNT-M; C2GnTM"
GCS1	GCS1-PEN; Glucosidase I
GCTG	gamma-glutamylcyclotransferase
GDA	guanine deaminase
GDH	glucose dehydrogenase
GFPT1	GFPT; Hs.1674; GFAT; glutamine-fructose-6-phosphate transaminase; GFA
GFPT2	glutamine-fructose-6-phosphate transaminase 2; GFAT2
GGCX	Hs.77719; gamma-glutamyl carboxylase
GGH	"GH; gamma-glutamyl hydrolase (conjugase, folylpolygammaglutamyl hydrolase)"
GGPS1	GGPPS; geranylgeranyl diphosphate synthase 1
GGT1	D22S672; D22S732; GGT; gamma-glutamyltransferase 1
GGT2	Hs.56312; GGT; gamma-glutamyltransferase 2
GGT3	gamma-glutamyltransferase 3
GGTA1	"GGTA; GLYT2; glycoprotein, alpha-galactosyltransferase 1"
GGTA1P	"GLYT3; glycoprotein, alpha-galactosyltransferase 1 pseudogene"
GGTL1	gamma-glutamyltransferase-like 1
GGTL2	gamma-glutamyltransferase-like 2
GGTL3	gamma-glutamyltransferase-like 3
GGTLA1	GGT-REL; gamma-glutamyltransferase-like activity 1
GK	Hs.1466; glycerol kinase deficiency
GKP1	glycerol kinase pseudogene 1
GKP2	Hs.2692; glycerol kinase pseudogene 2
GKP3	glycerol kinase pseudogene 3
GKP4	glycerol kinase pseudogene 4
GKP5	glycerol kinase pseudogene 5

Name	Description of Enzyme
GLA	"GALA; galactosidase, alpha"
GLB1	"galactosidase, beta 1; Hs.79222"
GLDC	"Hs.27; glycine dehydrogenase (decarboxylating; glycine decarboxylase, glycine cleavage system protein P)"
GLDCP	glycine dehydrogenase (decarboxylase) pseudogene
GLO1	Hs.75207; glyoxalase I
GLRA1	"STHE; glycine receptor, alpha 1 (startle disease/hyperekplexia, stiff man syndrome)"
GLRX	Hs.28988; glutaredoxin (thioltransferase); GRX
GLS	glutaminase
GLUD1	Hs.77508; GLUD; glutamate dehydrogenase 1
GLUD2	Glutamate dehydrogenase-2
GLUDP1	glutamate dehydrogenase pseudogene 1
GLUDP2	glutamate dehydrogenase pseudogene 2
GLUDP3	glutamate dehydrogenase pseudogene 3
GLUDP4	glutamate dehydrogenase pseudogene 4
GLUDP5	glutamate dehydrogenase pseudogene 5
GLUL	glutamate-ammonia ligase (glutamine synthase); Hs.1717; GLNS
GLULL1	glutamate-ammonia ligase (glutamine synthase)-like 1
GLULL2	glutamate-ammonia ligase (glutamine synthase)-like 2
GLULL3	glutamate-ammonia ligase (glutamine synthase)-like 3
GLULP	glutamate-ammonia ligase (glutamine synthase) pseudogene
GLYD	glycerate-2-dehydrogenase
GMDS	"GDP-mannose 4,6-dehydratase"
GMPR	guanine monophosphate reductase
GMPR2	guanosine monophosphate reductase 2
GMPS	GMPS-PEN; guanine monophosphate synthetase
GNE	GLCNE; UDP-N-acetylglucosamine-2-epimerase/N-acetylmannosamine kinase
GNPAT	DHAPAT; dihydroxyacetonephosphate acyltransferase; DAPAT
GNPTA	glucosamine (UDP-N-acetyl)-lysosomal-enzyme N-acetylglucosamine phosphotransferase (mucolipidoses II & III); mucolipidosis II; mucolipidosis III
GNS	Hs.2703; glucosamine (N-acetyl)-6-sulfatase (Sanfilippo disease IIID)
GOT1	"Hs.597; glutamic-oxaloacetic transaminase 1, soluble (aspartate aminotransferase 1)"
GOT2	"Hs.79365; glutamic-oxaloacetic transaminase 2, mitochondrial (aspartate aminotransferase 2)"
GOT2L1	glutamic-oxaloacetic transaminase 2-like 1
GOT2L2	glutamic-oxaloacetic transaminase 2-like 2
GOT2L3	glutamic-oxaloacetic transaminase 2-like 3
GPB	"glycerol phosphatase, beta-"
GPD1	glycerol-3-phosphate dehydrogenase 1 (soluble)
GPD2	Hs.93201; glycerol-3-phosphate dehydrogenase 2 (mitochondrial); Hs.89720
GPI	glucose phosphate isomerase; Hs.944
GPI1	N-acetylglucosaminyl transferase component Gpi1
GPLD1	glycosylphosphatidylinositol specific phospholipase D1
GPR3	G protein-coupled receptor 3; ACCA; adenylate cyclase constitutive activator

Name	Description of Enzyme
GPRK2L	G protein-coupled receptor kinase 2 (Drosophila)-like; GPRK4
GPRK5	GRK5; G protein-coupled receptor kinase 5
GPRK6	Hs.76297; GRK6; G protein-coupled receptor kinase 6
GPRK6P	GPRK6L; G protein-coupled receptor kinase 6 pseudogene; G protein-coupled receptor kinase 6-like
GPRK7	G protein-coupled receptor kinase 7
GPT	glutamic-pyruvate transaminase (alanine aminotransferase)
GPX1	Hs.76686; glutathione peroxidase 1
GPX2	Hs.2704; GSHPX-GI; glutathione peroxidase 2 (gastrointestinal)
GPX3	glutathione peroxidase 3 (plasma); Hs.81477
GPX4	Hs.2706; glutathione peroxidase 4 (phospholipid hydroperoxidase)
GPX5	glutathione peroxidase 5 (epididymal androgen-related protein)
GPX6	glutathione peroxidase 6 (olfactory)
GPX7	glutathione peroxidase 7
GPXP1	GPXL1; glutathione peroxidase pseudogene 1
GPXP2	GPXL2; glutathione peroxidase pseudogene 2
GRHPR	GLXR; glyoxylate reductase/hydroxypyruvate reductase
GSD1B	glycogen-storage disease type 1b
GSD1C	glycogen-storage disease type 1c
GSE	CD; Gluten-sensitive enteropathy (celiac disease)
GSK1	glycogen synthase kinase 1
GSK2	glycogen synthase kinase 2
GSK3A	glycogen synthase kinase 3 alpha
GSK3B	glycogen synthase kinase 3 beta
GSPT1	G1 to S phase transition 1; Hs.2707; GST1
GSR	glutathione reductase
GSS	Hs.82327; glutathione synthetase
GSTA1	Hs.100026; H-A; glutathione S-transferase A1; Hs.89552; Hs.99928
GSTA2	glutathione S-transferase A2; H-A; GST2
GSTA3	glutathione S-transferase A3
GSTA4	glutathione S-transferase A4
GSTAP1	glutathione S-transferase A pseudogene 1
GSTAP2	glutathione-S-transferase A pseudogene 2
GSTM1	Hs.99859; MU; H-B; GST1; glutathione S-transferase M1
GSTM1L	GST1L; glutathione S-transferase M1-like
GSTM2	Hs.73974; GST4; glutathione S-transferase M2 (muscle)
GSTM3	Hs.2006; GST5; glutathione S-transferase M3 (brain)
GSTM4	Hs.105976; glutathione S-transferase M4; Hs.82891
GSTM5	Hs.75652; glutathione S-transferase M5
GSTP1	FAEES3; glutathione S-transferase pi; fatty acid ethyl ester synthase III; PI; GST3
GSTPP	glutathione S-transferase pi pseudogene; GST3L; GSTPL
GSTT1	Hs.77490; glutathione S-transferase theta 1
GSTT2	Hs.1581; glutathione S-transferase theta 2
GSTTLP28	P28; glutathione-S-transferase like

Name	Description of Enzyme
GSTZ1	MAAI; glutathione S-transferase Zeta 1 (maleylacetoacetate isomerase)
GTA	GGTB1; galactosyltransferase activator
GUCA1A	GUCA1; guanylate cyclase activator 1A (retina); GUCA; GCAP; GCAP1
GUCA1B	guanylate cyclase activator 1B (retina); GCAP2
GUCA1C	GCAP3; guanylate cyclase activator 1C
GUCA2A	GUCA2; guanylate cyclase activator 2A (guanylin); Hs.778; STARA
GUCA2B	guanylate cyclase activator 2B; uroguanylin
GUCY1A2	"GUC1A2; guanylate cyclase 1, soluble, alpha 2; Hs.2685; GC-SA2"
GUCY1A3	"GUC1A3; guanylate cyclase 1, soluble, alpha 3; GC-SA3"
GUCY1B2	"guanylate cyclase 1, soluble, beta 2"
GUCY1B3	"GUC1B3; guanylate cyclase 1, soluble, beta 3; GC-SB3"
GUCY2C	GUC2C; guanylate cyclase 2C (heat stable enterotoxin receptor); guanylyl cyclase C; STAR
GUCY2D	"GUC2D; LCA; guanylate cyclase 2D, retina-specific (Leber congenital amaurosis 1); Leber congenital amaurosis; Hs.1974; GUC1A4; guanylate cyclase 2D, membrane (retina-specific); LCA1; retGC"
GUCY2E	guanylate cyclase 2E; GC-E
GUCY2F	"guanylate cyclase 2F, retinal; GUC2DL; GC-F; RetGC-2; guanylate cyclase 2D-like, membrane (retina-specific)"
GUK1	guanylate kinase 1
GUK2	guanylate kinase 2
GULOP	gulonolactone (L-) oxidase pseudogene; GLO; GULO
GUSB	"Hs.29174; glucuronidase, beta"
GUSM	"glucuronidase, beta (mouse) modifier of"
GYS1	Hs.772; GYS; glycogen synthase 1 (muscle)
GYS2	glycogen synthase 2 (liver)
GZMA	"CTLA3; granzyme A (granzyme 1, cytotoxic T-lymphocyte-associated serine esterase 3); HFSP"
GZMB	"CTLA1; granzyme B (granzyme 2, cytotoxic T-lymphocyte-associated serine esterase 1); CSPB; CCPI; CGL-1; CSP-B"
GZMK	"granzyme K (serine protease, granzyme 3; tryptase II); TRYP2; Hs.3066; PRSS; granzyme K (serine protease, granzyme 3); granzyme 3; tryptase II"
GZMM	MET1; LMET1; granzyme M (lymphocyte met-ase 1)
H6PD	hexose-6-phosphate dehydrogenase; glucose 1-dehydrogenase
HADH	hydroxyacyl-Coenzyme A dehydrogenase
HADH2	"hydroxyacyl-Coenzyme A dehydrogenase, type II; ERAB"
HADHA	"hydroxyacyl-Coenzyme A dehydrogenase/3-ketoacyl-Coenzyme A thiolase/enoyl-Coenzyme A hydratase (trifunctional protein), alpha subunit; Hs.75860; GBP"
HADHAP	hydroxyacyl-Coenzyme A dehydrogenase/3-ketoacyl-Coenzyme A thiolase/enoyl-Coenzyme A hydratase pseudogene (gastrin binding protein pseudogene)
HADHB	"hydroxyacyl-Coenzyme A dehydrogenase/3-ketoacyl-Coenzyme A thiolase/enoyl-Coenzyme A hydratase (trifunctional protein), beta subunit"
HADHSC	"L-3-hydroxyacyl-Coenzyme A dehydrogenase, short chain; SCHAD"
HAGH	hydroxyacyl glutathione hydrolase
HAL	Hs.89429; HIS; histidine ammonia-lyase

Name	Description of Enzyme
HAO	"HAO-PEN; 3-hydroxyanthranilate 3,4-dioxygenase"
HAO1	GOX1; hydroxyacid oxidase (glycolate oxidase) 1; GOX
HARS	Hs.2741; histidyl-tRNA synthetase
HAS1	HAS; hyaluronan synthase 1
HAS2	hyaluronan synthase 2
HAS3	hyaluronan synthase 3
HAT	airway trypsin-like protease
HAT1	histone acetyltransferase 1
HBACH	cytosolic acyl coenzyme A thioester hydrolase
HBOA	HBO1; histone acetyltransferase
HCCS	CCHL; holocytochrome c synthase (cytochrome c heme-lyase)
HCK	Hs.89555; JTK9; hemopoietic cell kinase; Hs.77058
HD	huntingtin (Huntington disease); Hs.79391; IT15
HDAC1	"RPD3L1; histone deacetylase 1; HD1; RPD3 (reduced potassium dependency, yeast, homolog)-like 1"
HDAC2	histone deacetylase 2
HDAC3	histone deacetylase 3
HDC	Hs.1481; histidine decarboxylase
HE1	"NPC2; NP-C2; Niemann-Pick disease, type C; epididymal secretory protein (19.5kD)"
HELLS	"helicase, lymphoid-specific; LSH"
HEP27	short-chain alcohol dehydrogenase family member
HERA-B	"HERA-A; GTPase, human homolog of E. coli essential cell cycle protein Era"
HEXA	hexosaminidase A (alpha polypeptide)
HEXB	Hs.51043; hexosaminidase B (beta polypeptide)
HGD	"AKU; homogentisate 1,2-dioxygenase (homogentisate oxidase); HGO; Hs.15113; Alcaptonuria"
HGS	human growth factor-regulated tyrosine kinase substrate; HRS; human growth factor-regulated tyrosine kinase substrate
HHCMA56	putative oxidoreductase
HIBADH	3-hydroxyisobutyrate dehydrogenase
HINT	PRKCNH1; histidine triad nucleotide-binding protein; protein kinase C inhibitor 1; PKCI-1
HIPK3	homeodomain-interacting protein kinase 3; PKY; DYRK6
HK1	Hs.75276; hexokinase 1
HK2	hexokinase 2
HK2P	hexokinase 2 pseudogene
HK3	Hs.94397; hexokinase 3 (white cell)
HLCS	holocarboxylase synthetase (biotin-[proprionyl-Coenzyme A-carboxylase (ATP-hydrolysing)] ligase); Hs.79375; HCS
HMBS	Hs.82609; UPS; PBGD; hydroxymethylbilane synthase
HMGCL	3-hydroxy-3-methylglutaryl-Coenzyme A lyase (hydroxymethylglutaricaciduria); Hs.831; HL
HMGCR	3-hydroxy-3-methylglutaryl-Coenzyme A reductase
HMGCS1	Hs.21808; HMGCS; 3-hydroxy-3-methylglutaryl-Coenzyme A synthase 1 (soluble)

Name	Description of Enzyme
HMGCS2	3-hydroxy-3-methylglutaryl-Coenzyme A synthase 2 (mitochondrial)
HMOX1	Hs.75967; heme oxygenase (decycling) 1
HMOX2	Hs.83853; HO-2; heme oxygenase (decycling) 2
HNK-1ST	HNK-1 sulfotransferase
HNMT	histamine N-methyltransferase
HPD	Hs.89831; PPD; 4-hydroxyphenylpyruvate dioxygenase
HPGD	hydroxyprostaglandin dehydrogenase 15-(NAD)
HPN	"hepsin (transmembrane protease, serine 1); Hs.823; TMPRSS1; hepsin"
HPRT1	Hs.82314; HPRT; HGPRT; hypoxanthine phosphoribosyltransferase 1 (Lesch-Nyhan syndrome)
HPRT2	hypoxanthine phosphoribosyltransferase 2
HPRTP1	hypoxanthine phosphoribosyltransferase pseudogene 1
HPRTP2	hypoxanthine phosphoribosyltransferase pseudogene 2
HPRTP3	hypoxanthine phosphoribosyltransferase pseudogene 3
HPRTP4	hypoxanthine phosphoribosyltransferase pseudogene 4
HPSE	HPA; HSE1; heparanase
HRMT1L1	"HMT1 (hnRNP methyltransferase, S. cerevisiae)-like 1; PRMT2"
HRMT1L2	"HMT1 (hnRNP methyltransferase, S. cerevisiae)-like 2; HCP1; PRMT1"
HS3ST1	heparan sulfate (glucosamine) 3-O-sulfotransferase 1
HS3ST2	heparan sulfate (glucosamine) 3-O-sulfotransferase 2
HS3ST3A1	heparan sulfate (glucosamine) 3-O-sulfotransferase 3A1
HS3ST3A2	heparan sulfate (glucosamine) 3-O-sulfotransferase 3A2
HS3ST3B1	heparan sulfate (glucosamine) 3-O-sulfotransferase 3B1
HS3ST3B2	heparan sulfate (glucosamine) 3-O-sulfotransferase 3B2
HS3ST4	heparan sulfate (glucosamine) 3-O-sulfotransferase 4
HS6ST	heparan-sulfate 6-sulfotransferase
HSA9947	putative ATPase
HSCR2	HSCR; Hirschsprung disease 2
HSD11B1	HSD11; HSD11B; hydroxysteroid (11-beta) dehydrogenase 1
HSD11B2	hydroxysteroid (11-beta) dehydrogenase 2
HSD17B1	HSD17; EDHB17; EDH17B2; hydroxysteroid (17-beta) dehydrogenase 1
HSD17B2	Hs.181; hydroxysteroid (17-beta) dehydrogenase 2
HSD17B3	Hs.477; hydroxysteroid (17-beta) dehydrogenase 3
HSD17B4	hydroxysteroid (17-beta) dehydrogenase 4
HSD17B5	hydroxysteroid (17-beta) dehydrogenase 5
HSD17BP1	HSD17; EDHB17; EDH17B1; hydroxysteroid (17-beta) dehydrogenase pseudogene 1
HSD3B1	"Hs.38586; HSDB3; HSD3B; hydroxy-delta-5-steroid dehydrogenase, 3 beta- and steroid delta-isomerase 1"
HSD3B2	"hydroxy-delta-5-steroid dehydrogenase, 3 beta- and steroid delta-isomerase 2"
HSD3B3	"HSD3B3-LSB; hydroxy-delta-5-steroid dehydrogenase, 3 beta- C(27); giant cell hepatitis, neonatal"
HSD3BP1	"hydroxy-delta-5-steroid dehydrogenase, 3 beta, pseudogene 1"
HSD3BP2	"hydroxy-delta-5-steroid dehydrogenase, 3 beta, pseudogene 2"
HSD3BP3	"hydroxy-delta-5-steroid dehydrogenase, 3 beta, pseudogene 3"
HSD3BP4	"hydroxy-delta-5-steroid dehydrogenase, 3 beta, pseudogene 4"

Name	Description of Enzyme
HSD3BP5	"hydroxy-delta-5-steroid dehydrogenase, 3 beta, pseudogene 5"
HTOR	5-hydroxytryptamine (serotonin) oxygenase regulator
HTR7	Hs.73739; 5-hydroxytryptamine (serotonin) receptor 7 (adenylate cyclase-coupled)
HU-K5	lysophospholipase-like
HYAL1	hyaluronoglucosaminidase 1; LUCA1; HYAL-1
HYAL2	LUCA-2; hyaluronoglucosaminidase 2
HYAL3	hyaluronoglucosaminidase 3; LUCA-3; LUCA14; Minna14
HYL	HYL-PEN; hematopoietic consensus tyrosine-lacking kinase
IARS	Hs.89412; ILRS; isoleucine-tRNA synthetase; Hs.78770
IBD1	inflammatory bowel disease 1; Crohn disease
IBGC1	idiopathic basal ganglia calcification 1; BGCI; IBGC; Fahr disease
ICB-1	basement membrane-induced gene
IDH1	"isocitrate dehydrogenase 1 (NADP+), soluble"
IDH2	"Hs.105969; isocitrate dehydrogenase 2 (NADP+), mitochondrial"
IDH3A	isocitrate dehydrogenase 3 (NAD+) alpha
IDH3B	isocitrate dehydrogenase 3 (NAD+) beta
IDH3G	isocitrate dehydrogenase 3 (NAD+) gamma
IDI1	isopentenyl diphosphate delta isomerase
IDO	"Hs.840; indole 2,3-dioxygenase"
IDS	iduronate 2-sulfatase (Hunter syndrome); Hs.79285; SIDS
IDSP1	IDS2; iduronate 2-sulfatase pseudogene 1
IDUA	"iduronidase, alpha-L-; Hs.89560"
IKBKAP	"inhibitor of kappa light polypeptide gene enhancer in B-cells, kinase complex-associated protein; IKAP"
IKBKB	"inhibitor of kappa light polypeptide gene enhancer in B-cells, kinase beta; IKK2; NFKBIKB; IKK-beta"
IKBKG	"inhibitor of kappa light polypeptide gene enhancer in B-cells, kinase gamma; NEMO; IKK-gamma"
IL17	CTLA8; interleukin 17 (cytotoxic T-lymphocyte-associated serine esterase 8); Hs.41724
ILF3	"interleukin enhancer binding factor 3, 90kD; M-phase phosphoprotein 4; NF90; MPP4; DRBP76; NFAR-1; MPHOSPH4; MMP4"
ILK	integrin-linked kinase; Hs.6196
ILVBL	AHAS; ILV2H; ilvB (bacterial acetolactate synthase)-like
IMPA1	IMPA; inositol(myo)-1(or 4)-monophosphatase 1
IMPA2	inositol(myo)-1(or 4)-monophosphatase 2
IMPDH1	Hs.850; IMP (inosine monophosphate) dehydrogenase 1; sWSS2608
IMPDH2	Hs.75432; IMP (inosine monophosphate) dehydrogenase 2
IMPDHL1	IMP (inosine monophosphate) dehydrogenase-like 1
INDO	"IDO; indoleamine-pyrrole 2,3 dioxygenase"
INMT	ndolethylamine N-methyltransferase; thioester S-methyltransferase-like; indolethylamine N-methyltransferase
INPP1	inositol polyphosphate-1-phosphatase; Hs.32309
INPP3	inositol polyphosphate-3-phosphatase
INPP4A	INPP4; inositol polyphosphate-4-phosphatase

Name	Description of Enzyme
INPP4B	"inositol polyphosphate-4-phosphatase, type II, 105kD"
INPP5A	"inositol trisphosphate-5-phosphatase, 40kD; inositol polyphosphate-5-phosphatase, 40kD"
INPP5B	"inositol polyphosphate-5-phosphatase, 75kD"
INPP5C	"inositol polyphosphate-5-phosphatase, 120kD"
INPP5D	"inositol polyphosphate-5-phosphatase, 145kD; SHIP; hp51CN"
INPPL1	Hs.75339; inositol polyphosphate phosphatase-like 1; SHIP2
IQGAP2	IQ motif containing GTPase activating protein 2
IRAK-M	interleukin-1 receptor-associated kinase M
IRAK1	interleukin-1 receptor-associated kinase; IRAK; Pelle (Drosophila) homolog; pelle
IRAK2	interleukin-1 receptor-associated kinase 2; IRAK-2
ITK	IL2-inducible T-cell kinase; EMT; T-cell-specific tyrosine kinase; homolog of mouse T-cell itk/tsk tyrosine kinase; PSCTK2
ITPA	inosine triphosphatase (nucleoside triphosphate pyrophosphatase)
ITPK1	"inositol 1,3,4-trisphosphate 5/6 kinase"
ITPKA	"Hs.2722; inositol 1,4,5-trisphosphate 3-kinase A"
ITPKB	"Hs.78877; inositol 1,4,5-trisphosphate 3-kinase B"
IVD	Hs.77510; isovaleryl Coenzyme A dehydrogenase
JAK1	JAK1A; Janus kinase 1 (a protein tyrosine kinase)
JAK2	Janus kinase 2 (a protein tyrosine kinase)
JAK3	"Hs.99877; L-JAK; Janus kinase 3 (a protein tyrosine kinase, leukocyte)"
JTK5A	JTK5A protein tyrosine kinase
JTK5B	JTK5B protein tyrosine kinase
KAPPA	"Kappa transcript, coding region similar to kinases"
KAR	Aromatic alpha-keto acid reductase
KARS	lysyl-tRNA synthetase
KATII	kynurenine aminotransferase II
KATNA1	katanin p60 (ATPase-containing) subunit A 1
KDR	kinase insert domain receptor (a type III receptor tyrosine kinase); Hs.12337; FLK1; VEGFR2
KHK	ketohexokinase (fructokinase); Hs.81454
KIAA0566	"ATP#; ATPase type IV, phospholipid transporting (P-type) (putative)"
KIAA0611	"ATP#; ATPase type IV, phospholipid-transporting (P-type),(putative)"
KIAA0660	G3BP2; Ras-GTPase activating protein SH3 domain-binding protein 2
KIAA0901	HDAC6; histone deacetylase 6
KIAA0928	helicase-moi
KIP2	DNA-dependent protein kinase catalytic subunit-interacting protein 2
KLK6	"PRSS9; kallikrein 6 (neurosin, zyme); protease, serine, 9 (neurosin); protease M"
KLK7	"PRSS6; kallikrein 7 (chymotryptic, stratum corneum); SCCE; protease, serine, 6 (chymotryptic, stratum corneum)"
KMO	kynurenine 3-monooxygenase (kynurenine 3-hydroxylase)
KNPEP	lysyl aminopeptidase (aminopeptidase Co)
KSR	KSR1; kinase suppressor of ras
KWE	keratolytic winter erythema (Oudtshoorn skin disease)

Name	Description of Enzyme
KYN	KYN-PEN; kynureninase
KYNU	kynureninase (L-kynurenine hydrolase)
LAP70	"apyrase, lysosomal"
LARGE	like-glycosyltransferase; KIAA0609
LARS	leucyl-tRNA synthetase
LAS	lipoic acid synthetase
LCAT	Hs.23513; lecithin-cholesterol acyltransferase; Norum disease; fish-eye disease
LCB2	"KIAA0526; serine palmitoyltransferase, subunit II"
LCK	Hs.1765; lymphocyte-specific protein tyrosine kinase
LCT	Hs.2251; lactase
LDHA	Hs.2795; lactate dehydrogenase A
LDHAL1	lactate dehydrogenase A-like 1
LDHAL2	lactate dehydrogenase A-like 2
LDHAL3	lactate dehydrogenase A-like 3
LDHAL4	lactate dehydrogenase A-like 4
LDHAL5	lactate dehydrogenase A-like 5
LDHB	Hs.74545; lactate dehydrogenase B
LDHBL1	lactate dehydrogenase B-like 1
LDHBP	LDHBL2; lactate dehydrogenase B pseudogene
LDHC	Hs.99881; lactate dehydrogenase C; Hs.511
LIG1	"Hs.1770; ligase I, DNA, ATP-dependent"
LIG2	"ligase II, DNA, ATP-dependent"
LIG3	"Hs.100299; ligase III, DNA, ATP-dependent"
LIG4	"ligase IV, DNA, ATP-dependent"
LIM	ENH; LIM protein (similar to rat protein kinase C-binding enigma)
LIMK1	LIMK; LIM domain kinase 1; Hs.36566; LIM motif-containing protein kinase
LIMK2	LIM domain kinase 2
LIPA	"Hs.85226; lipase A, lysosomal acid, cholesterol esterase (Wolman disease)"
LIPB	"lipase B, lysosomal acid"
LIPC	"Hs.9994; lipase, hepatic; HL"
LIPE	"lipase, hormone-sensitive; HSL"
LIPF	"HGL; HLAL; lipase, gastric"
LIPG	"EL; EDL; lipase, endothelial"
LKR/SDH	lysine-ketoglutarate reductase /saccharopine dehydrogenase
LNPEP	leucyl/cystinyl aminopeptidase (oxytocinase); CAP; PLAP
LOAD	late-onset Alzheimer disease susceptibility
LON	"LON-PEN; Lon, ATP-dependent protease (homolog of bacterial Lon)"
LOX	Hs.79234; lysyl oxidase
LOXL1	LOXL; lysyl oxidase-like 1
LOXL2	lysyl oxidase-like 2; WS9-14
LPAAT-BETA	lysophosphatidic acid acyltransferase beta
LPL	lipoprotein lipase; Hs.83122; LIPD
LPO	lactoperoxidase; SPO; salivary peroxidase
LRAT	lecithin retinol acyltransferase (phosphatidylcholine--retinol O-acyltransferase)

Name	Description of Enzyme
LSFC	"Leigh syndrome, French-Canadian type (cytochrome oxidase deficiency)"
LSK	LSK-PEN; leukocyte carboxyl-terminal src kinase related gene
LSS	"lanosterol synthase (2,3-oxidosqualene-lanosterol cyclase); OSC"
LTA4H	Hs.81118; leukotriene A4 hydrolase
LTB4HD	LTB4HD-PEN; leukotriene B4 12-hydroxydehydrogenase
LTC4S	Hs.456; leukotriene C4 synthase
LTK	Hs.210; TYK1; leukocyte tyrosine kinase
LYPLA1	lysophospholipase I; LPL1; APT-1; hLysoPLA
LYPLA2	lysophospholipase II; APT-2
MACS	"Hs.75607; 80K-L; MARCKS; myristoylated alanine-rich protein kinase C substrate (MARCKS, 80K-L)"
MACSL1	"myristoylated alanine-rich protein kinase C substrate (MARCKS, 80K-L)-like 1"
MAK	male germ cell-associated kinase
MAN1A1	"mannosidase, alpha, class 1A, member 1"
MAN1A2	"MAN1B; mannosidase, alpha, class 1A, member 2"
MAN1B1	"MANA-ER; mannosidase, alpha, class 1B, member 1"
MAN2A1	"MANA2; Hs.75296; mannosidase, alpha type II; Hs.32965"
MAN2A2	"mannosidase, alpha, class 2A, member 2; mannosidase, alpha type II-X; MANA2X"
MAN2B1	"MANB; Hs.89432; mannosidase, alpha B, lysosomal; LAMAN; Hs.375"
MAN2C1	"MANA1; MANA; mannosidase, alpha A, cytoplasmic"
MANBA	"mannosidase, beta A, lysosomal"
MANBB	"mannosidase, beta B, soluble"
MAOA	Hs.1782; monoamine oxidase A
MAOB	Hs.82163; monoamine oxidase B
MAP2K1	"PRKMK1; MEK1; MAPKK1; protein kinase, mitogen-activated, kinase 1 (MAP kinase kinase 1); MKK1"
MAP2K2	"PRKMK2; MEK2; protein kinase, mitogen-activated, kinase 2, p45 (MAP kinase kinase 2)"
MAP2K3	"PRKMK3; protein kinase, mitogen-activated, kinase 3 (MAP kinase kinase 3); MEK3; MKK3"
MAP2K4	SERK1; SAPK/Erk kinase 1; MEK4; JNKK1; PRKMK4
MAP2K5	"PRKMK5; protein kinase, mitogen-activated, kinase 5 (MAP kinase kinase 5); MEK5"
MAP2K6	"PRKMK6; protein kinase, mitogen-activated, kinase 6 (MAP kinase kinase 6); MEK6; MKK6; SAPKK3"
MAP2K7	"PRKMK7; MKK7; protein kinase, mitogen-activated, kinase 7 (MAP kinase kinase 7); Jnkk2; MAPKK7"
MAP3K1	MEKK1; MAP/ERK kinase kinase 1; MEKK; MAPKKK1
MAP3K10	"MLK2; mitogen-activated protein kinase kinase kinase 10; mixed lineage kinase 2 (tyr and ser/thr specificity); serine/threonine kinase, non-receptor type; MST"
MAP3K11	MLK3; mixed lineage kinase 3; PTK1; SPRK; MLK-3
MAP3K12	ZPK; zipper (leucine) protein kinase
MAP3K13	LZK; mitogen-activated protein kinase kinase kinase 13

Name	Description of Enzyme
MAP3K2	MEKK2; MAP3K2-PENDING; mitogen-activated protein kinase kinase kinase 2
MAP3K3	MEKK3; MAP/ERK kinase kinase 3; MAPKKK3
MAP3K4	MEKK4; MAP/ERK kinase kinase 4; MTK1; MAPKKK4
MAP3K5	MEKK5; MAP/ERK kinase kinase 5; ASK1; MAPKKK5
MAP3K6	mitogen-activated protein kinase kinase kinase 6; MAPKKK6
MAP3K7	TAK1; transforming growth factor beta-activated kinase 1
MAP3K9	MLK1; mixed lineage kinase 1 (tyr and ser/thr specificity); PRKE1
MAP4K1	HPK1; mitogen-activated protein kinase kinase kinase kinase 1
MAP4K2	RAB8IP; Rab8 interacting protein (GC kinase); GCK; BL44
MAP4K3	GLK; RAB8IPL1; mitogen-activated protein kinase kinase kinase kinase 3
MAP4K4	HGK; NIK; KIAA0687; mitogen-activated protein kinase kinase kinase kinase 4
MAP4K5	mitogen-activated protein kinase kinase kinase kinase 5; KHS; KHS-PEN; kinase homologous to SPS1/STE20; KHS1
MAPK1	"PRKM1; mitogen-activated protein kinase 1; PRKM2; protein kinase, mitogen-activated 1 (MAP kinase 1; p40, p41); ERK; ERK2; MAPK2; p41mapk; p38"
MAPK11	PRKM11; mitogen-activated protein kinase 11; protein kinase mitogen-activated 11; SAPK2; p38-2; p38Beta
MAPK12	SAPK3; stress-activated protein kinase 3; ERK6; PRKM12; p38gamma
MAPK13	PRKM13; protein kinase mitogen- activated 13; SAPK4; p38delta
MAPK14	CSBP1; CSBP2; cytokine suppressive anti-inflammatory drug binding protein 2 (p38 MAP kinase); CSPB1; cytokine suppressive anti-inflammatory drug binding protein 1; PRKM14; p38; Mxi2; PRKM15
MAPK3	"PRKM3; protein kinase, mitogen-activated 3 (MAP kinase 3; p44); ERK1; p44mapk; p44erk1"
MAPK4	"PRKM4; protein kinase, mitogen-activated 4 (MAP kinase 4; p63); Erk3-related; ERK3"
MAPK6	"PRKM6; protein kinase, mitogen-activated 6 (extracellular signal-regulated kinase, p97); protein kinase, mitogen-activated 5 (extracellular signal-regulated kinase, p97); ERK3; p97MAPK"
MAPK7	PRKM7; mitogen-activated protein kinase 7; BMK1; ERK5
MAPKAPK2	mitogen-activated protein kinase-activated protein kinase 2
MAPKAPK3	MAPKAP; 3pK; mitogen-activated protein kinase-activated protein kinase
MAPKAPK5	mitogen-activated protein kinase-activated protein kinase 5; PRAK
MARK1	MAP/microtubule affinity-regulating kinase 1
MARK3	MAP/microtubule affinity-regulating kinase 3; KP78
MARS	methionine-tRNA synthetase
MASP1	"PRSS5; MASP; protease, serine, 5 (mannose-binding protein-associated)"
MAT1A	"MAT; methionine adenosyltransferase I, alpha; SAMS; MATA1; SAMS1"
MAT2A	"methionine adenosyltransferase II, alpha; SAMS2; MATA2; MATII"
MATK	Hs.274; megakaryocyte-associated tyrosine kinase
MCCC1	methylcrotonoyl-Coenzyme A carboxylase 1 (alpha)
MCCC2	methylcrotonoyl-Coenzyme A carboxylase 2 (beta)
MCD	malonyl coenzyme A decarboxylase
MCKD1	medullary cystic kidney disease 1 (autosomal dominant); ADMCKD; MCD; MCKD; ADMCKD1

Name	Description of Enzyme
MCKD2	ADMCKD2; medullary cystic kidney disease 2 (autosomal dominant)
MDH1	"Hs.75375; malate dehydrogenase 1, NAD (soluble)"
MDH2	"malate dehydrogenase 2, NAD (mitochondrial)"
ME78	ME78-PEN; Metallo-endopeptidase(78KDa)(cleaves a beta-APP substrate peptide)
MEB	muscle-eye-brain disease
MED6	"RNA polymerase II transcriptional regulation mediator (Med6, S. cerevisiae, homolog of)"
MEP1A	"meprin A, alpha (PABA peptide hydrolase); PPHA"
MERTK	"c-mer proto-oncogene tyrosine kinase; MER; MER-PEN; protooncogene c-mer (tyrosine kinase expressed in monocytes, epithelial, and reproductive tissues); c-mer"
METTL1	methyltransferase-like 1; C12orf1; YDL201w
MGAM	MG; MGA; maltase-glucoamylase (alpha-glucosidase)
MGAT1	"mannosyl (alpha-1,3-)-glycoprotein beta-1,2-N-acetylglucosaminyltransferase; Hs.82148; GNT-I; MGAT; GLYT1; GLCNAC-TI"
MGAT2	"mannosyl (alpha-1,6-)-glycoprotein beta-1,2-N-acetylglucosaminyltransferase; GNT-II"
MGAT3	"mannosyl (beta-1,4-)-glycoprotein beta-1,4-N-acetylglucosaminyltransferase; Hs.112; GNT-III"
MGAT4A	"GNT-IV; GNT-IVA; mannosyl (alpha-1,3-)-glycoprotein beta-1,4-N-acetylglucosaminyltransferase, isoenzyme A"
MGAT4B	"GNT-IV; GNT-IVB; mannosyl (alpha-1,3-)-glycoprotein beta-1,4-N-acetylglucosaminyltransferase, isoenzyme B"
MGAT5	"mannosyl (alpha-1,6-)-glycoprotein beta-1,6-N-acetylglucosaminyltransferase; GNT-V"
MGEA5	MEA5; meningioma expressed antigen 5 (hyaluronidase)
MGMT	O-6-methylguanine-DNA methyltransferase; Hs.1384
MGST1	MGST; microsomal glutathione S-transferase 1; MGST-I; GST12
MGST1L1	PIG12; MGST-IV; microsomal glutathione S-transferase 1-like 1
MGST2	microsomal glutathione S-transferase 2; MGST-II
MGST3	microsomal glutathione S-transferase 3
MINPP1	MIPP; MINPP2; multiple inositol polyphosphate phosphatase 1
MIPEP	mitochondrial intermediate peptidase; MIP; HMIP
MJD	"Machado-Joseph disease (spinocerebellar ataxia 3, olivopontocerebellar ataxia 3, autosomal dominant, ataxin 3); ATX3; SCA3; Machado-Joseph disease"
MJD4	MJD4-PEN; Machado-Joseph disease-related 4
MJDL1	MJD2; Machado-Joseph disease-like-1
MKNK1	MNK1; MAP kinase-interacting serine/threonine kinase 1
MKP-L	MKP-1 like protein tyrosine phosphatase
MKP5	dual specificity phosphatase MKP-5
MLD	membrane fatty acid (lipid) desaturase
MMCP-7-LIKE-2	MMCP-7-LIKE-1; mast cell tryptase
MME	"membrane metallo-endopeptidase (neutral endopeptidase, enkephalinase, CALLA, CD10); Hs.1298; CD10; CALLA"
MMP1	Hs.83169; CLG; matrix metalloproteinase 1 (interstitial collagenase)

Name	Description of Enzyme
MMP10	Hs.2258; STMY2; matrix metalloproteinase 10 (stromelysin 2)
MMP11	STMY3; matrix metalloproteinase 11 (stromelysin 3)
MMP12	matrix metalloproteinase 12 (macrophage elastase); Hs.1695; HME
MMP13	Hs.2936; CLG3; matrix metalloproteinase 13 (collagenase 3)
MMP14	matrix metalloproteinase 14 (membrane-inserted); MT1-MMP
MMP15	matrix metalloproteinase 15 (membrane-inserted); MT2-MMP
MMP16	matrix metalloproteinase 16 (membrane-inserted); MT3-MMP
MMP17	matrix metalloproteinase 17 (membrane-inserted); MT4-MMP
MMP19	MMP18; matrix metalloproteinase 19; matrix metalloproteinase 18; RASI-1
MMP2	"Hs.80343; CLG4; CLG4A; matrix metalloproteinase 2 (gelatinase A, 72kD gelatinase, 72kD type IV collagenase); Hs.75399; Hs.75557"
MMP20	matrix metalloproteinase 20; enamelysin
MMP23A	MIFR; MMP21; MIFR-1; matrix metalloproteinase 23A
MMP23B	MMP22; matrix metalloproteinase 23B
MMP24	MT5-MMP; matrix metalloproteinase 24 (membrane-inserted)
MMP3	"Hs.83326; STMY; STMY1; matrix metalloproteinase 3 (stromelysin 1, progelatinase); Hs.46450"
MMP7	"Hs.2256; MPSL1; MMP-7; PUMP-1; matrix metalloproteinase 7 (matrilysin, uterine)"
MMP8	Hs.73862; CLG1; matrix metalloproteinase 8 (neutrophil collagenase)
MMP9	"CLG4B; matrix metalloproteinase 9 (gelatinase B, 92kD gelatinase, 92kD type IV collagenase)"
MMPL1	matrix metalloproteinase-like 1; MMP20; matrix metalloproteinase-like 1
MMSDH	methylmalonate-semialdehyde dehydrogenase
MOX1	mitogenic oxidase (pyridine nucleotide-dependent superoxide-generating)
MPG	Hs.79396; MDG; N-methylpurine-DNA glycosylase
MPI	Hs.75694; mannose phosphate isomerase
MPO	myeloperoxidase; Hs.1817
MPP-1	M-phase phosphoprotein 1
MPP-10	M phase phosphoprotein 10 (U3 small nucleolar ribonucleoprotein)
MPP-6	M-phase phosphoprotein 6
MPP-9	M phase phosphoprotein 9
MPST	mercaptopyruvate sulfurtransferase; MST
MSRA	methionine sulfoxide reductase A
MST-3	STE20-like kinase 3
MST1R	Hs.2942; RON; macrophage stimulating 1 receptor (c-met-related tyrosine kinase)
MTAP	Hs.3245; methylthioadenosine phosphorylase
MTAPP	MTAPP-PEN; methylthioadensine phosphorylase pseudogene
MTATP6	ATP synthase 6
MTATP8	ATP synthase 8
MTCO1	cytochrome c oxidase I
MTCO2	cytochrome c oxidase II
MTCO3	cytochrome c oxidase III

Name	Description of Enzyme
MTHFD1	"MTHFD; Hs.37791; MTHFC; 5,10-methylenetetrahydrofolate dehydrogenase, 5,10-methylenetetrahydrofolate cyclohydrolase, 10-formyltetrahydrofolate synthetase; Hs.1793"
MTHFD1P1	"MTHFDP1; MTHFDL1; 5,10-methylenetetrahydrofolate dehydrogenase, 5,10-methylenetetrahydrofolate cyclohydrolase, 10-formyltetrahydrofolate synthetase pseudogene 1"
MTHFD2	"NMDMC; methylene tetrahydrofolate dehydrogenase (NAD+ dependent), methenyltetrahydrofolate cyclohydrolase"
MTHFR	"5,10-methylenetetrahydrofolate reductase (NADPH)"
MTHFS	"MTHFS-PEN; 5,10-methenyltetrahydrofolate synthase"
MTND1	"NADH dehydrogenase, subunit 1 (complex I)"
MTND2	"NADH dehydrogenase, subunit 2 (complex I)"
MTND3	"NADH dehydrogenase, subunit 3 (complex I)"
MTND4	"NADH dehydrogenase, subunit 4 (complex I)"
MTND4L	"NADH dehydrogenase, subunit 4L (complex I)"
MTND5	"NADH dehydrogenase, subunit 5 (complex I)"
MTND6	"NADH dehydrogenase, subunit 6 (complex I)"
MTR	5-methyltetrahydrofolate-homocysteine methyltransferase
MTRF1	mitochondrial translational release factor 1; MTTRF1; RF1
MTRR	5-methyltetrahydrofolate-homocysteine methyltransferase reductase
MUSK	"muscle, skeletal, receptor tyrosine kinase"
MUT	methylmalonyl Coenzyme A mutase
MVD	mevalonate (diphospho) decarboxylase; MPD
MVK	mevalonate kinase (mevalonic aciduria); Hs.75138
MYHK	"myosin, heavy polypeptide kinase"
MYLK	"myosin, light polypeptide kinase"
MYLKP	"myosin, light polypeptide kinase pseudogene"
MYP1	"myopia 1 (X-linked, Bornholm eye disease included)"
MYPT1	"myosin phosphatase, target subunit 1; MBS"
MYPT2	"myosin phosphatase, target subunit 2"
NAADALASE2	NAALADASE2; N-acetylated alpha-linked acidic dipeptidase II
NAALADASEL	I100; N-acetylated alpha-linked acidic dipeptidase-like; ILEAL DIPEPTIDYLPEPTIDASE
NAGA	"N-acetylgalactosaminidase, alpha-; D22S674; Hs.75372; GALB"
NAGLU	"N-acetylglucosaminidase, alpha- (Sanfilippo disease IIIB); Hs.50727; NAG"
NARS	asparaginyl-tRNA synthetase
NAT1	AAC1; Hs.89391; arylamide acetylase 1 (N-acetyltransferase 1)
NAT2	"AAC2; Hs.2; arylamide acetylase 2 (N-acetyltransferase 2, isoniazid inactivation)"
NCF1	"Hs.1583; neutrophil cytosolic factor 1 (47kD, chronic granulomatous disease, autosomal 1); p47phox"
NCF2	"Hs.949; neutrophil cytosolic factor 2 (65kD, chronic granulomatous disease, autosomal 2); p67phox"
NCK1	NCK; Hs.54589; non-catalytic region of tyrosine kinase
NDP	Hs.2839; Norrie disease (pseudoglioma)

Name	Description of Enzyme
NDR	"NDR-LSB; serine/threonine kinase, nuclear Dfnb2-related (Drosophila) homolog"
NDST1	HSST; N-deacetylase/N-sulfotransferase (heparan glucosaminyl); heparan sulfate-N-deacetylase/N-sulfotransferase; Hs.20894; NST1
NDST2	N-deacetylase/N-sulfotransferase (heparan glucosaminyl) 2; NST2; HSST2; N-deacetylase/N-sulfotransferase (heparan glucosaminyl) 2
NDST3	N-deacetylase/N-sulfotransferase (heparan glucosaminyl) 3
NDUFA1	"NADH dehydrogenase (ubiquinone) 1 alpha subcomplex, 1 (7.5kD, MWFE); MWFE"
NDUFA10	"NADH dehydrogenase (ubiquinone) 1 alpha subcomplex, 10 (42kD)"
NDUFA2	"NADH dehydrogenase (ubiquinone) 1 alpha subcomplex, 2 (8kD, B8); B8"
NDUFA3	"NADH dehydrogenase (ubiquinone) 1 alpha subcomplex, 3 (9kD, B9); B9"
NDUFA4	"NADH dehydrogenase (ubiquinone) 1 alpha subcomplex, 4 (9kD, MLRQ); MLRQ"
NDUFA5	"NADH dehydrogenase (ubiquinone) 1 alpha subcomplex, 5 (13kD, B13); B13"
NDUFA5P1	"NADH dehydrogenase (ubiquinone) 1 alpha subcomplex, 5, pseudogene 1"
NDUFA6	"NADH dehydrogenase (ubiquinone) 1 alpha subcomplex, 6 (14kD, B14); B14"
NDUFA7	"NADH dehydrogenase (ubiquinone) 1 alpha subcomplex, 7 (14.5kD, B14.5a); B14.5a"
NDUFA8	"NADH dehydrogenase (ubiquinone) 1 alpha subcomplex, 8 (19kD, PGIV); PGIV"
NDUFA9	"NADH dehydrogenase (ubiquinone) 1 alpha subcomplex, 9 (39kD)"
NDUFAB1	"NADH dehydrogenase (ubiquinone) 1, alpha/beta subcomplex, 1 (8kD, SDAP); SDAP"
NDUFB1	"NADH dehydrogenase (ubiquinone) 1 beta subcomplex, 1 (7kD, MNLL); MNLL"
NDUFB10	"NADH dehydrogenase (ubiquinone) 1 beta subcomplex, 10 (22kD, PDSW); PDSW"
NDUFB2	"NADH dehydrogenase (ubiquinone) 1 beta subcomplex, 2 (8kD, AGGG); AGGG"
NDUFB3	"NADH dehydrogenase (ubiquinone) 1 beta subcomplex, 3 (12kD, B12); B12"
NDUFB4	"NADH dehydrogenase (ubiquinone) 1 beta subcomplex, 4 (15kD, B15); B15"
NDUFB5	"NADH dehydrogenase (ubiquinone) 1 beta subcomplex, 5 (16kD, SGDH); SGDH"
NDUFB6	"NADH dehydrogenase (ubiquinone) 1 beta subcomplex, 6 (17kD, B17); B17"
NDUFB7	"NADH dehydrogenase (ubiquinone) 1 beta subcomplex, 7 (18kD, B18); B18"
NDUFB8	"NADH dehydrogenase (ubiquinone) 1 beta subcomplex, 8 (19kD, ASHI); ASHI"
NDUFB9	"B22; NADH dehydrogenase (ubiquinone) 1 beta subcomplex, 9 (22kD, B22); UQOR22"
NDUFC1	"NADH dehydrogenase (ubiquinone) 1, subcomplex unknown, 1 (6kD, KFYI); KFYI"
NDUFC2	"NADH dehydrogenase (ubiquinone) 1, subcomplex unknown, 2 (14.5kD, B14.5b); B14.5b"
NDUFS1	NADH dehydrogenase (ubiquinone) Fe-S protein 1 (75kD) (NADH-coenzyme Q reductase); Hs.8248; NADH-UBIQUINONE OXIDOREDUCTASE 75 KD SUBUNIT PRECURSOR

Name	Description of Enzyme
NDUFS2	NADH dehydrogenase (ubiquinone) Fe-S protein 2 (49kD) (NADH-coenzyme Q reductase)
NDUFS2L	NADH dehydrogenase (ubiquinone) Fe-S protein 2-like (NADH-coenzyme Q reductase)
NDUFS3	NADH dehydrogenase (ubiquinone) Fe-S protein 3 (30kD) (NADH-coenzyme Q reductase)
NDUFS4	NADH dehydrogenase (ubiquinone) Fe-S protein 4 (18kD) (NADH-coenzyme Q reductase); AQDQ; mitochondrial respiratory chain complex I (18-KD subunit)
NDUFS5	NADH dehydrogenase (ubiquinone) Fe-S protein 5 (15kD) (NADH-coenzyme Q reductase)
NDUFS6	NADH dehydrogenase (ubiquinone) Fe-S protein 6 (13kD) (NADH-coenzyme Q reductase)
NDUFS7	NADH dehydrogenase (ubiquinone) Fe-S protein 7 (20kD) (NADH-coenzyme Q reductase); PSST
NDUFS8	NADH dehydrogenase (ubiquinone) Fe-S protein 8 (23kD) (NADH-coenzyme Q reductase)
NDUFV1	NADH dehydrogenase (ubiquinone) flavoprotein 1 (51kD)
NDUFV2	Hs.51299; NADH dehydrogenase (ubiquinone) flavoprotein 2 (24kD)
NDUFV2P1	NADH dehydrogenase (ubiquinone) flavoprotein 2 pseudogene 1
NDUFV3	NADH dehydrogenase (ubiquinone) flavoprotein 3 (10kD)
NEK1	NIMA (never in mitosis gene a)-related kinase 1
NEK2	NIMA (never in mitosis gene a)-related kinase 2; NLK; 1 HSPK 21
NEK3	NIMA (never in mitosis gene a)-related kinase 3
NEK4	NIMA (never in mitosis gene a)-related kinase 4; NLK2
NEK5	NIMA (never in mitosis gene a)-related kinase 5; NLK3
NEK6	NIMA (never in mitosis gene a)-related kinase 6
NEU1	NEU; neuraminidase; sialidase
NEU2	sialidase 2 (cytosolic sialidase)
NEU3	neuraminidase 3 (membrane sialidase)
NF1	"neurofibromin 1 (neurofibromatosis, von Recklinghausen disease, Watson disease); Hs.93207; Hs.37170; Hs.89393"
NGAP	ras GTPase activating protein-like
NIFS	cysteine desulfurase
NIK	HS; HSNIK; serine/threonine protein-kinase
NIPSNAP1	4-nitrophenylphosphatase domain and non-neuronal SNAP25-like 1
NIT1	nitrilase 1
NM23-H6	NME6; IPIA-ALPHA; nucleoside diphosphate kinase type 6 (inhibitor of p53-induced apoptosis-alpha)
NME4	"non-metastatic cells 4, protein expressed in (nucleoside-diphosphate kinase); nm23-H4"
NME5	"non-metastatic cells 5, protein expressed in (nucleoside-diphosphate kinase)"
NMOR2	"Hs.73956; NQO2; NAD(P)H menadione oxidoreductase 2, dioxin-inducible"
NMT1	NMT; N-myristoyltransferase
NMT2	N-myristoyltransferase 2
NNMT	nicotinamide N-methyltransferase
NNT	NNT-PEN; nicotinamide nucleotide transhydrogenase

Name	Description of Enzyme
NOD1	CARD4; caspase recruitment domain 4
NOS1	Hs.46752; NOS; nitric oxide synthase 1 (neuronal)
NOS2A	"Hs.946; NOS2; nitric oxide synthase 2A (inducible, hepatocytes)"
NOS2B	nitric oxide synthase 2B
NOS2C	nitric oxide synthase 2C
NOS3	nitric oxide synthase 3 (endothelial cell); Hs.76983; consitutive endothelial nitric oxide synthase; ECNOS
NP	Hs.75514; nucleoside phosphorylase
NPC1	"NPC; Niemann-Pick disease, type C1"
NPR1	NPRA; ANPRA; GUC2A; natriuretic peptide receptor A/guanylate cyclase A (atrionatriuretic peptide receptor A)
NPR2	NPRB; ANPRB; GUC2B; natriuretic peptide receptor B/guanylate cyclase B (atrionatriuretic peptide receptor B)
NPR2L	homologous to yeast nitrogen permease (candidate tumor suppressor)
NRD1	nardilysin (N-arginine dibasic convertase) 1; hNRD1; hNRD2
NRGN	"neurogranin (protein kinase C substrate, RC3); RC3"
NSEP1	DBPB; nuclease sensitive element binding protein 1
NSMAF	neutral sphingomyelinase (N-SMase) activation associated factor; FAN
NT3	3' nucleotidase
NT5	Hs.76856; CD73; 5' nucleotidase (CD73); Hs.2382
NT5CP	NT5CP-LSB; cytosolic purine 5' nucleotidase
NTE	neuropathy target esterase
NTHL1	nth (E.coli endonuclease III)-like 1; NTH1; OCTS3
NTRK1	"TRK; neurotrophic tyrosine kinase, receptor, type 1"
NTRK2	"TRKB; neurotrophic tyrosine kinase, receptor, type 2"
NTRK3	"Hs.26776; TRKC; neurotrophic tyrosine kinase, receptor, type 3"
NTRKR1	neurotrophic tyrosine kinase receptor-related 1; Ror1
NTRKR2	neurotrophic tyrosine kinase receptor-related 2; Ror2
NUDT1	"MTH1; Hs.388; mutT (E. coli) human homolog (8-oxo-7,8-dihydroguanosine triphosphatase)"
NUDT2	"APAH1; Ap4A hydrolase 1 (diadenosine 5',5"""-P1,P4-tetraphosphate pyrophosphohydrolase)"
NY-CO-9	HDAC5; histone deacetylase 5; KIAA0600
OAS1	"OIAS; 2',5'-oligoadenylate synthetase; Hs.82396; IFI-4"
OAS2	2'-5'oligoadenylate synthetase 2
OAS3	2'-5'oligoadenylate synthetase 3
OASL	TRIP14; 2'-5'oligoadenylate synthetase-like
OAT	Hs.75485; ornithine aminotransferase (gyrate atrophy)
OATL1	ornithine aminotransferase-like 1
OATL2	ornithine aminotransferase-like 2
OATL3	ornithine aminotransferase-like 3
OAZ1	OAZ; ornithine decarboxylase antizyme
OAZ2	ornithine decarboxylase antizyme 2
OC90	PLA2L; otoconin 90; phospholipase A2-like
ODC1	Hs.75212; ornithine decarboxylase 1
ODCP	ODC2; ornithine decarboxylase pseudogene

Name	Description of Enzyme
OED	Oregon eye disease
OGDH	Hs.75533; oxoglutarate dehydrogenase (lipoamide)
OGG1	8-oxoguanine DNA glycosylase
OGT	O-GLCNAC; O-linked N-acetylglucosamine (GlcNAc) transferase (UDP-N-acetylglucosamine:polypeptide-N-acetylglucosaminyl transferase)
OTC	Hs.1842; ornithine carbamoyltransferase
OVD1A	2-oxoisovalerate dehydrogenase (lipoamide)
OXA1L	oxidase (cytochrome c) assembly 1-like
OXCT	3-oxoacid CoA transferase; SCOT
P-CIP1	peptidylglycine alpha-amidating monooxygenase COOH-terminal interactor protein-1
P11	PP11; placental protein 11 (serine proteinase)
P4HA1	"P4HA; Hs.89513; procollagen-proline, 2-oxoglutarate 4-dioxygenase (proline 4-hydroxylase), alpha polypeptide; Hs.76768"
P4HA2	"procollagen-proline, 2-oxoglutarate 4-dioxygenase (proline 4-hydroxylase), alpha polypeptide II"
P4HB	"ERBA2L; procollagen-proline, 2-oxoglutarate 4-dioxygenase (proline 4-hydroxylase), beta polypeptide (protein disulfide isomerase; thyroid hormone binding protein p55); Hs.89698; PO4DB; v-erb-a avian erythroblastic leukemia viral oncogene homolog 2-like; Hs.75655"
P4HBR	"P4HBR-PEN; Procollagen-proline, 2-oxyglutarate 4-dioxygenase(proline 4-hydrolase), beta polypeptide (protein disulfide isomerase)-related"
P5	protein disulfide isomerase-related protein
PACSIN2	protein kinase C and casein kinase substrate in neurons 2
PAFAH1B1	"platelet-activating factor acetylhydrolase, isoform Ib, alpha subunit (45kD); LIS1; PAFAH; lissencephaly 1"
PAFAH1B2	"platelet-activating factor acetylhydrolase, isoform Ib, beta subunit (30kD)"
PAFAH1B3	"platelet-activating factor acetylhydrolase, isoform Ib, gamma subunit (29kD)"
PAFAH2	platelet-activating factor acetylhydrolase 2 (40kD)
PAH	phenylalanine hydroxylase; Hs.1870
PAICS	"PAIS; phosphoribosylaminoimidazole carboxylase, phosphoribosylaminoribosylaminoimidazole succinocarboxamide synthetase"
PAICSP1	"phosphoribosylaminoimidazole carboxylase, phosphoribosylaminoimidazole succinocarboxamide synthetase carboxylase pseudogene 1"
PAICSP2	"phosphoribosylaminoimidazole carboxylase, phosphoribosylaminoimidazole succinocarboxamide synthetase pseudogene 2"
PAK1	p21/Cdc42/Rac1-activated kinase 1 (yeast Ste20-related)
PAK2	p21 (CDKN1A)-activated kinase 2; hPAK65
PAK3	"MRX30; p21 (CDKN1A)-activated kinase 3; mental retardation, X-linked 30; bPAK; hPAK3"
PAK4	"protein kinase related to S. cerevisiae STE20, effector for Cdc42Hs"
PAM	Hs.83920; peptidylglycine alpha-amidating monooxygenase
PAP	poly(A) polymerase
PAPSS1	3'-phosphoadenosine 5'-phosphosulfate synthase 1; PAPSS; ATPSK1
PAPSS2	SK2; ATPSK2; 3-prime-phosphoadenosine 5-prime-phosphosulfate synthase 2
PARG	poly (ADP-ribose) glycohydrolase
PARK2	"Parkinson disease (autosomal recessive, juvenile) 2; PDJ; AR-JP; parkin"

Name	Description of Enzyme
PARK3	"Parkinson disease, dominant Lewy-body, 3"
PARN	poly(A)-specific ribonuclease (deadenylation nuclease)
PC	Hs.89890; pyruvate carboxylase; PCB
PC4	PC4-LSB; activated RNA polymerase II transcription cofactor; activated RNA polymerase II transcription cofactor 1; activated RNA polymerase II transcription cofactor 4; P15
PCBD	Hs.3192; PCD; DCOH; 6-pyruvoyl-tetrahydropterin synthase/dimerization cofactor of hepatocyte nuclear factor 1 alpha (TCF1); pterin-4-alpha carbinolamine dehydratase
PCCA	"Hs.80741; propionyl Coenzyme A carboxylase, alpha polypeptide"
PCCB	"Hs.63788; propionyl Coenzyme A carboxylase, beta polypeptide"
PCK1	Hs.1872; phosphoenolpyruvate carboxykinase 1 (soluble)
PCK2	PEPCK; phosphoenolpyruvate carboxykinase 2 (mitochondrial)
PCLD	PLD1; polycystic liver disease; PLD
PCMT1	protein-L-isoaspartate (D-aspartate) O-methyltransferase
PCOLC	procollagen C-endopeptidase
PCOLCE	procollagen C-endopeptidase enhancer; Hs.91299
PCOLN3	procollagen (type III) N-endopeptidase
PCSK1	Hs.78977; PC1; NEC1; PC-1; proprotein convertase subtilisin/kexin type 1
PCSK2	Hs.93164; PC2; NEC2; PC-2; proprotein convertase subtilisin/kexin type 2
PCSK3	proprotein convertase subtilisin/kexin type 3
PCSK4	PC4; proprotein convertase subtilisin/kexin type 4
PCSK5	proprotein convertase subtilisin/kexin type 5
PCSK7	PC8; PC7; LPC; SPC7; proprotein convertase subtilisin/kexin type 7; Lymphoma Proprotein Convertase
PCTK1	1; PCTGAIRE; PCTAIRE protein kinase 1
PCTK2	PCTAIRE protein kinase 2
PCTK3	Hs.2994; 3; PCTAIRE; PCTAIRE protein kinase 3
PCYT1A	"PCYT1; phosphate cytidylyltransferase 1, choline; CT; CTPCT"
PCYT1B	"CCT-BETA; phosphate cytidylyltransferase 1, choline, beta isoform"
PCYT2	"phosphate cytidylyltransferase 2, ethanolamine; ET"
PDB1	PDB; Paget disease of bone 1
PDB2	Paget disease of bone 2
PDE10A	phosphodiesterase 10A
PDE1A	"phosphodiesterase 1A, calmodulin-dependent; Hs.41717; Human 3',5' cyclic nucleotide phosphodiesterase (HSPDE1A3A)"
PDE1B	"PDES1B; phosphodiesterase 1B, calmodulin-dependent"
PDE1C	"phosphodiesterase 1C, calmodulin-dependent (70kD); HCAM3; Hs.41718; Human 3',5' cyclic nucleotide phosphodiesterase (HSPDE1C1A)"
PDE2A	"phosphodiesterase 2A, cGMP-stimulated; Hs.3831; Human cGMP-stimulated 3',5'-cyclic nucleotide phosphodiesterase PDE2A3 (PDE2A) mRNA, complete cds"
PDE3A	"phosphodiesterase 3A, cGMP-inhibited; CGI-PDE"
PDE3B	"phosphodiesterase 3B, cGMP-inhibited"
PDE4A	"Hs.96083; DPDE2; phosphodiesterase 4A, cAMP-specific (dunce (Drosophila)-homolog phosphodiesterase E2)"

Name	Description of Enzyme
PDE4B	"Hs.188; DPDE4; PDEIVB; phosphodiesterase 4B, cAMP-specific (dunce (Drosophila)-homolog phosphodiesterase E4)"
PDE4C	"Hs.189; DPDE1; phosphodiesterase 4C, cAMP-specific (dunce (Drosophila)-homolog phosphodiesterase E1)"
PDE4D	"DPDE3; phosphodiesterase 4D, cAMP-specific (dunce (Drosophila)-homolog phosphodiesterase E3)"
PDE5A	"phosphodiesterase 5A, cGMP-specific"
PDE6A	"phosphodiesterase 6A, cGMP-specific, rod, alpha; PDEA"
PDE6B	"phosphodiesterase 6B, cGMP-specific, rod, beta (congenital stationary night blindness 3, autosomal dominant); Hs.2593; CSNB3; PDEB"
PDE6C	"phosphodiesterase 6C, cGMP-specific, cone, alpha prime"
PDE6D	"phosphodiesterase 6D, cGMP-specific, rod, delta"
PDE6G	"phosphodiesterase 6G, cGMP-specific, rod, gamma; Hs.1857; PDEG"
PDE6H	"phosphodiesterase 6H, cGMP-specific, cone, gamma"
PDE7A	phosphodiesterase 7A; HCP1
PDE8A	phosphodiesterase 8A
PDE8B	phosphodiesterase 8B
PDE9A	phosphodiesterase 9A
PDHA1	Hs.1023; PDHA; pyruvate dehydrogenase (lipoamide) alpha 1
PDHA2	PDHAL; pyruvate dehydrogenase (lipoamide) alpha 2
PDHB	Hs.979; pyruvate dehydrogenase (lipoamide) beta
PDI	PDI-PEN; protein disulfide isomerase(pancreas)
PDI2	"KIAA0994; peptidyl arginine deiminase, type II"
PDIR	for protein disulfide isomerase-related
PDK1	"pyruvate dehydrogenase kinase, isoenzyme 1; Hs.81233"
PDK2	"pyruvate dehydrogenase kinase, isoenzyme 2"
PDK3	"pyruvate dehydrogenase kinase, isoenzyme 3"
PDK4	"pyruvate dehydrogenase kinase, isoenzyme 4; Hs.57695"
PDNP1	NPPS; M6S1; PC-1; phosphodiesterase I/nucleotide pyrophosphatase 1 (homologous to mouse Ly-41 antigen)
PDNP2	ATX; phosphodiesterase I/nucleotide pyrophosphatase 2 (autotaxin); autotaxin; PD-IALPHA
PDNP3	phosphodiesterase I/nucleotide pyrophosphatase 3; PD-IBETA
PDPK1	PDK1; PkB kinase
PDX1	"pyruvate dehydrogenase complex, component X; protein X"
PDXK	"pyridoxal (pyridoxine, vitamin B6) kinase; PKH; PNK"
PECI	"peroxisomal D3,D2-enoyl-CoA isomerase"
PEMT	phosphatidylethanolamine N-methyltransferase; PEMT2; PEMPT
PEN11B	putative serine/threonine protein kinase
PEPA	peptidase A
PEPB	peptidase B
PEPC	peptidase C
PEPD	Hs.73947; peptidase D
PEPE	peptidase E
PEPS	peptidase S

Name	Description of Enzyme
PFAS	phosphoribosylformylglycinamidine synthase (FGAR amidotransferase); A putative Human homolog of PHOSPHORIBOSYLFORMYLGLYCINAMIDINE SYNTHASE; PURL; KIAA0361; FGARAT
PFKFB1	"Hs.739; PFRX; 6-phosphofructo-2-kinase/fructose-2,6-biphosphatase 1"
PFKFB2	"6-phosphofructo-2-kinase/fructose-2,6-biphosphatase 2"
PFKFB3	"6-phosphofructo-2-kinase/fructose-2,6-biphosphatase 3"
PFKFB4	"6-phosphofructo-2-kinase/fructose-2,6-biphosphatase 4"
PFKL	"phosphofructokinase, liver; Hs.100005"
PFKM	"Hs.75160; phosphofructokinase, muscle"
PFKP	"Hs.99910; phosphofructokinase, platelet; Hs.75363"
PFKX	"phosphofructokinase, polypeptide X"
PFTK1	PFTAIRE protein kinase 1
PGAM1	Hs.74575; PGAMA; phosphoglycerate mutase 1 (brain)
PGAM2	Hs.46039; phosphoglycerate mutase 2 (muscle)
PGCP	plasma glutamate carboxypeptidase
PGD	Hs.75888; phosphogluconate dehydrogenase
PGDL1	phosphogluconate dehydrogenase-like 1
PGGT1B	"protein geranylgeranyltransferase type I, beta subunit; GGTI; BGGI"
PGK1	Hs.78771; phosphoglycerate kinase 1
PGK1P1	"phosphoglycerate kinase 1, pseudogene 1"
PGK1P2	"phosphoglycerate kinase 1, pseudogene 2"
PGK2	phosphoglycerate kinase 2
PGM1	phosphoglucomutase 1; Hs.1869
PGM2	phosphoglucomutase 2
PGM3	phosphoglucomutase 3
PGM5	phosphoglucomutase 5
PGP	phosphoglycolate phosphatase
PGS1	Phosphatidylglycerophosphate Synthase
PHEX	"HYP; phosphate regulating gene with homologies to endopeptidases on the X chromosome (hypophosphatemia, vitamin D resistant rickets); PEX; HPDR"
PHGDH	phosphoglycerate dehydrogenase; PGAD; 3-phosphoglycerate dehydrogenase; PDG; PGDH; SERA
PHKA1	"phosphorylase kinase, alpha 1 (muscle); Hs.2393; PHKA; phosphorylase kinase, alpha 1 (muscle), muscle glycogenosis"
PHKA2	"PHK; phosphorylase kinase, alpha 2 (liver); phosphorylase kinase deficiency, liver (glycogen storage disease type VIII); PYK; XLG; XLG2; PYKL; phosphorylase kinase, alpha 2 (liver), glycogen storage disease IX"
PHKB	"phosphorylase kinase, beta"
PHKBP1	"phosphorylase kinase, beta pseudogene 1"
PHKBP2	"phosphorylase kinase, beta pseudogene 2"
PHKG1	"PHKG; phosphorylase kinase, gamma 1 (muscle)"
PHKG2	"Hs.87452; phosphorylase kinase, gamma 2 (testis)"
PHKGL	"phosphorylase kinase, gamma-like"
PHYH	phytanoyl-CoA hydroxylase (Refsum disease); PAHX; Refsum disease

Name	Description of Enzyme
PI	"Hs.102128; PI1; protease inhibitor 1 (anti-elastase), alpha-1-antitrypsin; Hs.75621; Hs.99978; Hs.100021"
PI10	"protease inhibitor 10 (ovalbumin type, bomapin)"
PI12	protease inhibitor 12 (neuroserpin)
PI13	protease inhibitor 13
PI14	protease inhibitor 14 (pancpin)
PI3	"Hs.37072; ESI; SKALP; ELAFIN; protease inhibitor 3, skin-derived (SKALP)"
PI4	protease inhibitor 4 (kallistatin)
PI5	protease inhibitor 5 (maspin); Hs.55279
PI6	PTI; CAP; protease inhibitor 6 (placental thrombin inhibitor)
PI7	PNI; protease inhibitor 7 (protease nexin I)
PI8	protease inhibitor 8 (ovalbumin type); CAP-2
PI8L1	protease inhibitor 8 (ovalbumin type)-like 1
PI8L2	protease inhibitor 8 (ovalbumin type)-like 2
PI9	CAP-3; protease inhibitor 9 (ovalbumin type)
PICK1	"Protein that Interacts with C Kinase, 1"
PIG3	quinone oxidoreductase homolog
PIG6	proline oxidase homolog
PIK3C2A	"phosphatidylinositol 3-kinase, class 2, alpha polypeptide"
PIK3C2B	"phosphatidylinositol 3-kinase, class 2, beta polypeptide; C2-PI3K; PI3K-C2beta"
PIK3C2G	"phosphatidylinositol 3-kinase, class 2, gamma polypeptide"
PIK3C3	"phosphatidylinositol 3-kinase, class 3; Vps34"
PIK3CA	"phosphatidylinositol 3-kinase, catalytic, alpha polypeptide"
PIK3CB	"phosphatidylinositol 3-kinase, catalytic, beta polypeptide; PIK3C1"
PIK3CD	"phosphatidylinositol 3-kinase, catalytic, delta polypeptide; p110d"
PIK3CG	"phosphatidylinositol 3-kinase, catalytic, gamma polypeptide; Hs.32942"
PIK3R1	"phosphatidylinositol 3-kinase, regulatory subunit, polypeptide 1 (p85 alpha); GRB1"
PIK3R2	"P85B; phosphatidylinositol 3-kinase, regulatory subunit, polypeptide 2 (p85 beta)"
PIK3R3	"phosphoinositide-3-kinase, regulatory subunit, polypeptide 3 (p55, gamma)"
PIK4CA	"phosphatidylinositol 4-kinase, catalytic, alpha polypeptide; PI4K-ALPHA"
PIK4CB	"phosphatidylinositol 4-kinase, catalytic, beta polypeptide; PI4Kbeta"
PIL	protease inhibitor 1 (alpha-1-antitrypsin)-like
PIN	associated protein inhibitor of neuronal nitric oxide synthase
PIN1	"peptidyl-prolyl cis/trans isomerase, NIMA-interacting; dod"
PIN1L	"peptidyl-prolyl cis/trans isomerase, NIMA-interacting-like"
PIN1L2	protein (peptidyl-prolyl cis/trans isomerase) NIMA-interacting 1-like 2
PIN4	"protein (peptidyl-prolyl cis/trans isomerase) NIMA-interacting, 4 (parvulin)"
PIP5K1A	"phosphatidylinositol-4-phosphate 5-kinase, type I, alpha"
PIP5K1B	"phosphatidylinositol-4-phosphate 5-kinase, type I, beta; MSS4 protein (Saccharomyces cerevisiae) homolog; STM7-LSB; STM7; MSS4"
PIP5K1C	"phosphatidylinositol-4-phosphate 5-kinase, type I, gamma; KIAA0589"
PIP5K2A	"phosphatidylinositol-4-phosphate 5-kinase, type II, alpha"

Name	Description of Enzyme
PIP5K2B	"phosphatidylinositol-4-phosphate 5-kinase, type II, beta; PIP5KIIB"
PIS	phosphatidylinositol synthase
PK428	ser-Thr protein kinase related to the myotonic dystrophy protein kinase
PKD1	Hs.75813; PBP; polycystic kidney disease 1 (autosomal dominant)
PKD2	polycystic kidney disease 2 (autosomal dominant) -Note: redefinition of symbol; Hs.82001; PKD4
PKD2L1	PKD2L; PKDL; polycystic kidney disease 2-like 1; polycystin-like
PKD3	polycystic kidney disease 3 (autosomal dominant); APKD3
PKDREJ	"polycystic kidney disease (polycystin) and REJ (sperm receptor for egg jelly, sea urchin homolog)-like"
PKDTS	"polycystic kidney disease, infantile severe, with tuberous sclerosis"
PKHD1	ARPKD; polycystic kidney and hepatic disease 1 (autosomal recessive)
PKIA	"PRKACN1; protein kinase, cAMP-dependent, catalytic, inhibitor 1"
PKIB	"PRKACN2; protein kinase, cAMP-dependent, catalytic, inhibitor 2"
PKIG	"protein kinase (cAMP-dependent, catalytic) inhibitor gamma"
PKLR	"Hs.95990; pyruvate kinase, liver and RBC"
PKM2	"pyruvate kinase, muscle; Hs.990; OIP3"
PKMYT1	MYT1; membrane-associated tyrosine- and threonine-specific cdc2-inhibitory kinase
PLA2G10	"phospholipase A2, group X; GXPLA2"
PLA2G1B	"PLA2; PPLA2; PLA2A; phospholipase A2, group IB (pancreas)"
PLA2G2A	"phospholipase A2, group IIA (platelets, synovial fluid); Hs.76422; PLA2L; PLA2B"
PLA2G2C	"phospholipase A2, group IIC (possible pseudogene)"
PLA2G2D	"phospholipase A2, group IID; secretory phospholipase A2s; sPLA2S"
PLA2G4A	"PLA2G4; phospholipase A2, group IVA (cytosolic, calcium-dependent); Hs.3278; phospholipase A2, group IV"
PLA2G4B	"CPLA2-BETA; phospholipase A2, group IVB (cytosolic)"
PLA2G4C	"CPLA2-GAMMA; phospholipase A2, group IVC (cytosolic, calcium-independent)"
PLA2G5	"phospholipase A2, group V"
PLA2G6	"phospholipase A2, group VI; iPLA2"
PLA2G7	"phospholipase A2, group VII (platelet-activating factor acetylhydrolase, plasma); PAFAH; LDL-PLA2; phospholipase A2, group VII (platelet-activating factor acetylhydrolase, plasma)"
PLA2R1	"PLA2R; phospholipase A2 receptor 1, 180kD"
PLAA	phospholipase A2-activating protein; PLAP; phospholipase A2-activating protein
PLAU	"Hs.77274; plasminogen activator, urokinase"
PLAUR	"Hs.89857; plasminogen activator, urokinase receptor; Hs.83170"
PLCB2	"Hs.994; phospholipase C, beta 2"
PLCB3	"phospholipase C, beta 3 (phosphatidylinositol-specific)"
PLCB4	"Hs.74014; phospholipase C, beta 4"
PLCD1	"phospholipase C, delta 1"
PLCD3	"phospholipase C, delta 3"
PLCE	"phospholipase C, epsilon; PLC-L"

Name	Description of Enzyme
PLCG1	"Hs.993; PLC1; phospholipase C, gamma 1 (formerly subtype 148)"
PLCG2	"phospholipase C, gamma 2 (phosphatidylinositol-specific); Hs.75648"
PLD1	"phospholipase D1, phosphatidylcholine-specific"
PLD2	phospholipase D2
PLK	polo (Drosophia)-like kinase
PLOD	"procollagen-lysine, 2-oxoglutarate 5-dioxygenase (lysine hydroxylase, Ehlers-Danlos syndrome type VI); Hs.75093; LLH; LH"
PLOD2	"procollagen-lysine, 2-oxoglutarate 5-dioxygenase (lysine hydroxylase) 2"
PLOD3	"procollagen-lysine, 2-oxoglutarate 5-dioxygenase (lysine hydroxylase) 3; LH3"
PLP1	"PLP; proteolipid protein (Pelizaeus-Merzbacher disease, spastic paraplegia 2, uncomplicated); Hs.1787; SPG2"
PLSCR1	phospholipid scramblase 1
PMM1	phosphomannomutase 1; Hs.75835
PMM2	CDG1; phosphomannomutase 2; CDGS; carbohydrate-deficient glycoprotein syndrome 1
PMM2P1	phosphomannomutase 2 pseudogene 1; PMM2psi
PMPCB	MPPB; MPP11; MPPP52; peptidase (mitochondrial processing) beta
PMS1	PMSL1; postmeiotic segregation increased (S. cerevisiae) 1
PMS2	PMSL2; postmeiotic segregation increased (S. cerevisiae) 2
PMS2L1	postmeiotic segregation increased 2-like 1; PMS3
PMS2L10	postmeiotic segregation increased 2-like 10; PMSR4
PMS2L11	postmeiotic segregation increased 2-like 11; PMSR6
PMS2L12	postmeiotic segregation increased 2-like 12; PMSL12
PMS2L2	postmeiotic segregation increased 2-like 2; PMS4
PMS2L3	postmeiotic segregation increased 2-like 3; PMS5
PMS2L4	postmeiotic segregation increased 2-like 4; PMS6
PMS2L5	postmeiotic segregation increased 2-like 5; PMS7
PMS2L6	postmeiotic segregation increased 2-like 6; PMS8
PMS2L7	postmeiotic segregation increased 2-like 7; PMSR1
PMS2L8	postmeiotic segregation increased 2-like 8; PMSR2
PMS2L9	postmeiotic segregation increased 2-like 9; PMSR3
PMS2LP1	postmeiotic segregation increased 2-like pseudogene 1; PMSR5
PMS2LP2	postmeiotic segregation increased 2-like pseudogene 2; PMSR7
PMVK	PMK; PMK-PEN; phosphomevalonate kinase
PNKP	polynucleotide kinase 3-prime-phosphatase
PNLIP	Hs.99950; pancreatic lipase; Hs.1108
PNLIPRP1	PLRP1; pancreatic lipase-related protein 1
PNLIPRP2	PLRP2; pancreatic lipase-related protein 2
PNMT	Hs.1892; PENT; phenylethanolamine N-methyltransferase
PNMTP1	phenylethanolamine N-methyltransferase pseudogene 1
PNPO	PYRIDOXINE-5-PRIME-PHOSPHATE OXIDASE
POLA	"Hs.81942; polymerase (DNA directed), alpha"
POLB	"Hs.1894; polymerase (DNA directed), beta"
POLD1	"Hs.65383; POLD; polymerase (DNA directed), delta 1, catalytic subunit (125kD)"
POLD2	"polymerase (DNA directed), delta 2, regulatory subunit (50kD)"

Name	Description of Enzyme
POLE	"polymerase (DNA directed), epsilon"
POLE2	"polymerase (DNA directed), epsilon 2; DPE2"
POLG	"Hs.80961; polymerase (DNA directed), gamma"
POLG2	"polymerase (DNA directed), gamma 2, accessory subunit; HP55; POLB; MTPOLB; polymerase (DNA directed), gamma 2, accessory subunit"
POLH	"polymerase (DNA directed), eta; XP-V; RAD30A"
POLI	RAD30B; polymerase (DNA directed) iota; RAD30 (S. cerevisiae) homolog B
POLQ	"polymerase (DNA-directed), theta"
POLR2A	polymerase (RNA) II (DNA directed) polypeptide A (220kD); Hs.60366; POLR2; POLRA
POLR2B	polymerase (RNA) II (DNA directed) polypeptide B (140kD)
POLR2C	Hs.79402; polymerase (RNA) II (DNA directed) polypeptide C (33kD)
POLR2D	polymerase (RNA) II (DNA directed) polypeptide D
POLR2E	polymerase (RNA) II (DNA directed) polypeptide E (25kD)
POLR2F	polymerase (RNA) II (DNA directed) polypeptide F
POLR2G	polymerase (RNA) II (DNA directed) polypeptide G; RPB7
POLR2H	polymerase (RNA) II (DNA directed) polypeptide H
POLR2I	polymerase (RNA) II (DNA directed) polypeptide I (14.5kD)
POLR2J	polymerase (RNA) II (DNA directed) polypeptide J (13.3kD)
POLR2K	polymerase (RNA) II (DNA directed) polypeptide K (7.0kD)
POLR2L	polymerase (RNA) II (DNA directed) polypeptide L (7.6kD)
POLRMT	polymerase (RNA) mitochondrial (DNA directed); h-mtRPOL
POMT1	protein-O-mannosyltransferase 1
PON1	paraoxonase 1; PON
PON2	paraoxonase 2
PON3	paraoxonase 3
POR	P450 (cytochrome) oxidoreductase
PP	pyrophosphatase (inorganic)
PP2C-DELTA	"protein phosphatase 2c, delta isozyme"
PPAP2A	PAP-2A; phosphatidic acid phosphatase type 2a
PPAP2B	PAP-2B; phosphatidic acid phosphatase type 2b
PPAP2C	PAP-2C; phosphatidic acid phosphatase type 2c
PPAT	Hs.311; GPAT; phosphoribosyl pyrophosphate amidotransferase
PPATP1	phosphoribosyl pyrophosphate amidotransferase pseudogene 1
PPEF1	"PPEF; protein phosphatase, EF hand calcium-binding domain 1; PPEF-1"
PPEF2	"protein phosphatase, EF hand calcium-binding domain 2; PPEF-2"
PPFIA1	"protein tyrosine phosphatase, receptor type, f polypeptide (PTPRF), interacting protein (liprin), alpha 1"
PPFIA2	"protein tyrosine phosphatase, receptor type, f polypeptide (PTPRF), interacting protein (liprin), alpha 2"
PPFIA3	"protein tyrosine phosphatase, receptor type, f polypeptide (PTPRF), interacting protein (liprin), alpha 3; KIAA0654"
PPFIA4	"protein tyrosine phosphatase, receptor type, f polypeptide (PTPRF), interacting protein (liprin), alpha 4"
PPGB	Hs.985; GSL; protective protein for beta-galactosidase (galactosialidosis)
PPIA	peptidylprolyl isomerase A (cyclophilin A)

Name	Description of Enzyme
PPIB	Hs.699; CYPB; peptidylprolyl isomerase B (cyclophilin B)
PPIC	peptidylprolyl isomerase C (cyclophilin C); CYPC
PPID	hCyP40; CYP-40; peptidylprolyl isomerase D (cyclophilin D)
PPIE	CYP-33; peptidylprolyl isomerase E (cyclophilin E)
PPIF	peptidylprolyl isomerase F (cyclophilin F); CYP3; peptidylprolyl isomerase F (cyclophilin F)
PPIL1	peptidylprolyl isomerase (cyclophilin)-like 1
PPIP1	peptidylprolyl isomerase (cyclophilin) pseudogene 1
PPIP10	peptidylprolyl isomerase (cyclophilin) pseudogene 10; CRP; peptidylprolyl isomerase (cyclophilin) pseudogene 10
PPIP2	peptidylprolyl isomerase (cyclophilin) pseudogene 2
PPIP3	peptidylprolyl isomerase (cyclophilin) pseudogene 3
PPIP4	peptidylprolyl isomerase (cyclophilin) pseudogene 4
PPIP5	peptidylprolyl isomerase (cyclophilin) pseudogene 5
PPIP6	peptidylprolyl isomerase (cyclophilin) pseudogene 6
PPIP7	peptidylprolyl isomerase (cyclophilin) pseudogene 7
PPIP8	peptidylprolyl isomerase (cyclophilin) pseudogene 8
PPIP9	peptidylprolyl isomerase (cyclophilin) pseudogene 9
PPM1A	"protein phosphatase 1A (formerly 2C), magnesium-dependent, alpha isoform"
PPM1B	"protein phosphatase 1B (formerly 2C), magnesium-dependent, beta isoform"
PPM1D	"WIP1; protein phosphatase 1D magnesium-dependent, delta isoform"
PPM1G	"protein phosphatase 1G (formerly 2C), magnesium-dependent, gamma isoform; PPP2CG; protein phosphatase 2, catalytic subunit, gamma isoform; PP2Cgamma"
PPM2C	"protein phosphatase 2C, magnesium-dependent, catalytic subunit"
PPMT	PCCMT; HSTE14; prenylcysteine carboxyl methlytransferase
PPOX	PPO; protoporphyrinogen oxidase
PPP1CA	"Hs.78092; PPP1A; protein phosphatase 1, catalytic subunit, alpha isoform"
PPP1CB	"Hs.21537; protein phosphatase 1, catalytic subunit, beta isoform"
PPP1CC	"Hs.79081; protein phosphatase 1, catalytic subunit, gamma isoform"
PPP1R10	"protein phosphatase 1, regulatory subunit 10; FB19; PNUTS"
PPP1R1A	"protein phosphatase 1, regulatory (inhibitor) subunit 1A"
PPP1R1B	"DARPP-32; protein phosphatase 1, regulatory (inhibitor) subunit 1B (dopamine and cAMP regulated phosphoprotein, DARPP-32)"
PPP1R2	"protein phosphatase 1, regulatory (inhibitor) subunit 2"
PPP1R2P	"IPP-2P; protein phosphatase 1, regulatory (inhibitor) subunit 2 pseudogene"
PPP1R3	"protein phosphatase 1, regulatory (inhibitor) subunit 3 (glycogen and sarcoplasmic reticulum binding subunit, skeletal muscle); Hs.54496; PPP1R3A"
PPP1R5	"protein phosphatase 1, regulatory (inhibitor) subunit 5"
PPP1R6	"protein phosphatase 1, regulatory subunit 6 (NOTE: redefinition of symbol)"
PPP1R7	"protein phosphatase 1, regulatory subunit 7; sds22"
PPP1R8	"protein phosphatase 1, regulatory (inhibitor) subunit 8; ARD1; ard-1; NIPP-1"
PPP1R8P	"protein phosphatase 1, regulatory (inhibitor) subunit 8 pseudogene"
PPP1R9	"protein phosphatase 1, regulatory subunit 9, spinophilin"
PPP2CA	"Hs.78852; protein phosphatase 2 (formerly 2A), catalytic subunit, alpha isoform"

Name	Description of Enzyme
PPP2CB	"protein phosphatase 2 (formerly 2A), catalytic subunit, beta isoform"
PPP2CBP	"protein phosphatase 2 (formerly 2A), catalytic subunit, beta isoform pseudogene"
PPP2R1A	"protein phosphatase 2 (formerly 2A), regulatory subunit A (PR 65), alpha isoform"
PPP2R1B	"protein phosphatase 2 (formerly 2A), regulatory subunit A (PR 65), beta isoform; Hs.89608"
PPP2R2A	"Hs.75200; protein phosphatase 2 (formerly 2A), regulatory subunit B (PR 52), alpha isoform"
PPP2R2B	"protein phosphatase 2 (formerly 2A), regulatory subunit B (PR 52), beta isoform"
PPP2R2C	"protein phosphatase 2 (formerly 2A), regulatory subunit B (PR 52), gamma isoform"
PPP2R3	"Hs.89; protein phosphatase 2 (formerly 2A), regulatory subunit B" (PR 72), alpha isoform and (PR 130), beta isoform"
PPP2R4	"KIAA0044; Hs.78978; PTPA; protein phosphatase 2A, regulatory subunit B' (PR 53)"
PPP2R5A	"protein phosphatase 2, regulatory subunit B (B56), alpha isoform"
PPP2R5B	"protein phosphatase 2, regulatory subunit B (B56), beta isoform"
PPP2R5C	"protein phosphatase 2, regulatory subunit B (B56), gamma isoform"
PPP2R5D	"protein phosphatase 2, regulatory subunit B (B56), delta isoform"
PPP2R5E	"protein phosphatase 2, regulatory subunit B (B56), epsilon isoform"
PPP3CA	"Hs.92; CALN; CNA1; CCN1; CALNA; PPP2B; protein phosphatase 3 (formerly 2B), catalytic subunit, alpha isoform (calcineurin A alpha)"
PPP3CB	"protein phosphatase 3 (formerly 2B), catalytic subunit, beta isoform (calcineurin A beta); Hs.1335; CALNB"
PPP3CC	"protein phosphatase 3 (formerly 2B), catalytic subunit, gamma isoform (calcineurin A gamma)"
PPP3R1	"protein phosphatase 3 (formerly 2B), regulatory subunit B (19kD), alpha isoform (calcineurin B, type I)"
PPP3R2	"protein phosphatase 3 (formerly 2B), regulatory subunit B (19kD), beta isoform (calcineurin B, type II)"
PPP4C	"PP4; Hs.2903; protein phosphatase 4 (formerly X), catalytic subunit"
PPP4R1	"protein phosphatase 4, regulatory subunit 1; PP4R1"
PPP5C	"protein phosphatase 5, catalytic subunit; Hs.75180; PPP5"
PPP6C	"protein phosphatase 6, catalytic subunit"
PPT	"palmitoyl-protein thioesterase (ceroid-lipofuscinosis, neuronal 1, infantile; Haltia-Santavuori disease); CLN1; INCL"
PPT2	palmitoyl-protein thioesterase 2
PRCP	prolylcarboxypeptidase (angiotensinase C); PCP; HUMPCP
PREP	prolyl endopeptidase; Hs.86978; PEP
PRIM1	primase polypeptide 1 (49kD); Hs.82741
PRIM1P1	"primase polypeptide 1, pseudogene 1"
PRIM2A	Hs.74519; PRIM2; primase polypeptide 2A (58kD)
PRIM2B	PRIM2; primase polypeptide 2B (58kD)
PRKA1	protein kinase A1
PRKA2	protein kinase A2

Name	Description of Enzyme
PRKAA1	"protein kinase, AMP-activated, alpha 1 catalytic subunit; AMPK alpha 1"
PRKAA2	"PRKAA; protein kinase, AMP-activated, alpha 2 catalytic subunit; protein kinase, AMP-activated; AMPK"
PRKAB1	"protein kinase, AMP-activated, beta 1 non-catalytic subunit; AMPK beta 1"
PRKAB2	"protein kinase, AMP-activated, beta 2 non-catalytic subunit; AMPK beta 2"
PRKACA	"Hs.77271; protein kinase, cAMP-dependent, catalytic, alpha"
PRKACB	"Hs.1903; protein kinase, cAMP-dependent, catalytic, beta"
PRKACG	"protein kinase, cAMP-dependent, catalytic, gamma"
PRKAG1	"protein kinase, AMP-activated, gamma 1 non-catalytic subunit; AMPK gamma 1"
PRKAG2	"protein kinase, AMP-activated, gamma 2 non-catalytic subunit; AMPK gamma 2"
PRKAR1A	"Hs.62039; TSE1; PRKAR1; protein kinase, cAMP-dependent, regulatory, type I, alpha (tissue specific extinguisher 1); CNC1; Carney myxoma-endocrine complex, type 1"
PRKAR1AP	"protein kinase, cAMP-dependent, regulatory, type I, alpha pseudogene"
PRKAR1B	"Hs.1519; protein kinase, cAMP-dependent, regulatory, type I, beta"
PRKAR2A	"PRKAR2; protein kinase, cAMP-dependent, regulatory, type II, alpha"
PRKAR2B	"Hs.77439; PRKAR2; protein kinase, cAMP-dependent, regulatory, type II, beta"
PRKCA	"protein kinase C, alpha; Hs.60762; PKCA"
PRKCB1	"Hs.77767; PKCB; PRKCB; PRKCB2; protein kinase C, beta 1"
PRKCBP1	protein kinase C binding protein 1; RACK7
PRKCBP2	protein kinase C binding protein 2; RACK17
PRKCD	"Hs.458; protein kinase C, delta"
PRKCDBP	"SRBC; C-RAF-1; protein kinase C, delta binding protein"
PRKCE	"protein kinase C, epsilon"
PRKCG	"protein kinase C, gamma; Hs.2890; PKCG"
PRKCH	"PRKCL; PKC-L; protein kinase C, eta"
PRKCI	"DXS1179E; Hs.1904; PKCI; protein kinase C, iota"
PRKCL1	protein kinase C-like 1; DBK; PRK1; PKN; serine-threonine kinase N
PRKCL2	protein kinase C-like 2; PRK2
PRKCM	"Hs.2891; PKCM; protein kinase C, mu"
PRKCN	"protein kinase C, nu; EPK2; serine-threonine protein kinase; PKCnu"
PRKCQ	"Hs.89615; protein kinase C, theta"
PRKCSH	protein kinase C substrate 80K-H; Hs.1432; G19P1
PRKCZ	"Hs.78793; protein kinase C, zeta"
PRKDC	"HYRC1; protein kinase, DNA-activated, catalytic polypeptide; XRCC7; hyper-radiosensitivity of murine scid mutation, complementing 1; DNAPK"
PRKG1	"PRKG1B; PRKGR1B; protein kinase, cGMP-dependent, type I; PGK; cGKI; protein kinase, cGMP-dependent, regulatory, type I, beta"
PRKG2	"Protein kinase, cGMP-dependent, type II; cGKII; PRKGR2"
PRKR	"Hs.73821; PKR; protein kinase, interferon-inducible double stranded RNA dependent"
PRKRA	"protein kinase, interferon-inducible double stranded RNA dependent activator; RAX; PACT"

Name	Description of Enzyme
PRKRI	"protein-kinase, interferon-inducible double stranded RNA dependent inhibitor; P58"
PRKRIR	"protein-kinase, interferon-inducible double stranded RNA dependent inhibitor, repressor of (P58 repressor)"
PRKX	"protein kinase, X-linked; PKX1"
PRKXP1	"protein kinase, X-linked, pseudogene 1"
PRKXP2	"protein kinase, X-linked, pseudogene 2"
PRKY	"protein kinase, Y-linked"
PRMT3	protein arginine N-methyltransferase 3(hnRNP methyltransferase S. cerevisiae)-like 3
PRNP	"Hs.74621; CJD; PRIP; prion protein (p27-30) (Creutzfeld-Jakob disease, Gerstmann-Strausler-Scheinker syndrome, fatal familial insomnia)"
PRODH	proline dehydrogenase (proline oxidase)
PROSC	proline synthetase co-transcribed (bacterial homolog)
PRP4	PR4H; serine/threonine-protein kinase PRP4 homolog
PRPS1	Hs.74093; phosphoribosyl pyrophosphate synthetase 1; PRS I; Hs.56
PRPS1L1	PRPSL; phosphoribosyl pyrophosphate synthetase 1-like 1
PRPS1L2	phosphoribosyl pyrophosphate synthetase 1-like 2
PRPS2	Hs.2910; phosphoribosyl pyrophosphate synthetase 2; PRS II
PRPSAP1	PAP39; phosphoribosyl pyrophosphate synthetase-associated protein 1
PRPSAP2	phosphoribosyl pyrophosphate synthetase-associated protein 2; PAP41
PRSC1	"protease, cysteine, 1 (legumain); legumain"
PRSM1	"protease, metallo, 1, 33kD; KIAA0047; Hs.57302"
PRSM2	"protease, metallo, 2"
PRSS#	thymus specific serine peptidase
PRSS1	"Hs.73981; TRY1; cationic trypsinogen; hereditary pancreatitis; protease, serine, 1 (trypsin 1); HPC; PCTT"
PRSS11	"protease, serine, 11 (IGF binding)"
PRSS12	"BSSP-3; protease, serine, 12 (neurotrypsin, motopsin)"
PRSS15	"LONP; HLON; LONHS; PRSS15-PENDING; protease, serine, 15"
PRSS17	"PSTS; KLK4; EMSP1; protease, serine, 17 (enamel matrix, prostate)"
PRSS19	"HNP; protease, serine, 19 (neuropsin/ovasin)"
PRSS2	"Hs.105977; TRY2; protease, serine, 2 (trypsin 2)"
PRSS21	"protease, serine, 21 (testisin); TEST1; testisin; ESP-1; serine protease from eosinophils"
PRSS3	"Hs.58247; TRY3; protease, serine, 3 (trypsin 3)"
PRSS4	"TRY4; protease, serine, 4 (trypsin 4, brain)"
PRSS7	"protease, serine, 7 (enterokinase); Hs.3113"
PRSS8	"protease, serine, 8 (prostasin)"
PRSSL1	"protease, serine-like, 1; NES1"
PRTN3	"Hs.928; PR-3; ACPA; C-ANCA; proteinase 3 (serine proteinase, neutrophil, Wegener granulomatosis autoantigen)"
PSA	puromycin-sensitive aminopeptidase
PSAP	Hs.78575; SAP1; GLBA; prosaposin (variant Gaucher disease and variant metachromatic leukodystrophy)
PSEN1	AD3; presenilin 1 (Alzheimer disease 3); Hs.46464; FAD; S182; PS1

Name	Description of Enzyme
PSEN2	AD4; presenilin 2 (Alzheimer disease 4); AD3L; Hs.25363; STM2; PS2; Alzheimer's disease 3-like
PSKH1	putative serine kinase H1 (symbol provisional)
PSMB8	"proteasome (prosome, macropain) subunit, beta type, 8 (large multifunctional protease 7); D6S216; D6S216E; LMP7; RING10"
PSMB9	"proteasome (prosome, macropain) subunit, beta type, 9 (large multifunctional protease 2); LMP2; RING12"
PSMC1	"proteasome (prosome, macropain) 26S subunit, ATPase, 1; S4; P56"
PSMC2	"proteasome (prosome, macropain) 26S subunit, ATPase, 2; S7; MSS1"
PSMC3	"proteasome (prosome, macropain) 26S subunit, ATPase, 3; TBP1"
PSMC3P	"proteasome (prosome, macropain) 26S subunit, ATPase, 3 pseudogene"
PSMC4	"proteasome (prosome, macropain) 26S subunit, ATPase, 4; S6; TBP7"
PSMC5	"proteasome (prosome, macropain) 26S subunit, ATPase, 5; S8; P45; TRIP1"
PSMC6	"proteasome (prosome, macropain) 26S subunit, ATPase, 6; p42"
PSMD1	"proteasome (prosome, macropain) 26S subunit, non-ATPase, 1; S1; P112"
PSMD10	"proteasome (prosome, macropain) 26S subunit, non-ATPase, 10"
PSMD11	"proteasome (prosome, macropain) 26S subunit, non-ATPase, 11"
PSMD12	"proteasome (prosome, macropain) 26S subunit, non-ATPase, 12"
PSMD13	"proteasome (prosome, macropain) 26S subunit, non-ATPase, 13"
PSMD2	"S2; P97; TRAP2; proteasome (prosome, macropain) 26S subunit, non-ATPase, 2"
PSMD3	"S3; P58; proteasome (prosome, macropain) 26S subunit, non-ATPase, 3"
PSMD4	"proteasome (prosome, macropain) 26S subunit, non-ATPase, 4; S5A"
PSMD5	"S5B; proteasome (prosome, macropain) 26S subunit, non-ATPase, 5"
PSMD6	"proteasome (prosome, macropain) 26S subunit, non-ATPase, 6; S10"
PSMD7	"proteasome (prosome, macropain) 26S subunit, non-ATPase, 7 (Mov34 homolog); S12; P40; MOV34"
PSMD8	"proteasome (prosome, macropain) 26S subunit, non-ATPase, 8; S14"
PSMD9	"proteasome (prosome, macropain) 26S subunit, non-ATPase, 9"
PSPH	PSP; phosphoserine phosphatase
PSPHL	CO9; phosphoserine phosphatase-like
PSTPIP1	proline-serine-threonine phosphatase interacting protein 1; CD2 cytoplasmic tail-binding protein; H-PIP; PSTPIP; CD2BP1; CD2BP1L; CD2BP1S
PSTPIP2	MAYP; proline-serine-threonine phosphatase interacting protein 2
PTE1	peroxisomal acyl-CoA thioesterase; hTE; hNAACTE; thioesterase II
PTEN	phosphatase and tensin homolog (mutated in multiple advanced cancers 1); MMAC1
PTENP1	"phosphatase and tensin homolog (mutated in multiple advanced cancers 1), pseudogene 1; PTH2; PTEN2; psiPTEN; PTEN-rs"
PTER	RPR-1; phosphotriesterase-related
PTGDS	"prostaglandin D2 synthase (21kD, brain)"
PTGIS	prostaglandin I2 (prostacyclin) synthase; PGIS; CYP8; CYP8A1
PTGS1	Hs.88474; prostaglandin-endoperoxide synthase 1 (prostaglandin G/H synthase and cyclooxygenase)
PTGS2	Hs.89581; COX-2; prostaglandin-endoperoxide synthase 2 (prostaglandin G/H synthase and cyclooxygenase); COX2; Hs.89495
PTK2	FAK; PTK2 protein tyrosine kinase

Name	Description of Enzyme
PTK2B	protein tyrosine kinase 2 beta; PTK; FAK2; CAKB; PYK2; RAFTK
PTK3B	PTK3B protein tyrosine kinase 3B
PTK4	PTK4 protein tyrosine kinase
PTK5	PTK5 protein tyrosine kinase
PTK6	PTK6 protein tyrosine kinase 6; BRK; breast tumor kinase (non-receptor protein tyrosine kinase expressed in breast)
PTK7	Hs.9374; PTK7 protein tyrosine kinase
PTK8	PTK8 protein tyrosine kinase
PTK9	protein tyrosine kinase 9; A6
PTK9L	A6RP; protein tyrosine kinase 9-like (A6-related protein)
PTP-J	PCP-2; PTP-PI; protein tyrosine phosphatase J
PTP4A1	"protein tyrosine phosphatase type IVA, member 1; PRL-1; PTPCAAX1"
PTP4A2	"PTP4A; protein tyrosine phosphatase type IVA, member 2; OV-1; PRL-2; HU-PP-1; PTPCAAX2; ptp-IV1a"
PTP4A3	"PRL-3; protein tyrosine phosphatase type IVA, member 3"
PTP4AP1	protein tyrosine phosphatase IVA pseudogene 1
PTP4AP2	protein tyrosine phosphatase type IVA pseudogene 2
PTPGMC1	"protein-tyrosine phosphatase, receptor-type, expressed by glomerular mesangial cells"
PTPLA	"protein tyrosine phosphatase-like (proline instead of catalytic arginine), member a"
PTPLB	"protein tyrosine phosphatase-like (proline instead of catalytic arginine), member b"
PTPLC	"protein tyrosine phosphatase-like (proline instead of catalytic arginine), member c"
PTPN1	"Hs.81444; PTP1B; PTP-1B; protein tyrosine phosphatase, non-receptor type 1"
PTPN11	"Hs.22868; BPTP3; SH-PTP2; protein tyrosine phosphatase, non-receptor type 11"
PTPN12	"protein tyrosine phosphatase, non-receptor type 12; Hs.62; PTPG1; PTP-PEST"
PTPN13	"protein tyrosine phosphatase, nonreceptor type 13; PTP1E; PTP-BAS; protein tyrosine phosphatase, non-receptor type 13 (APO-1/CD95 (Fas)-associated phosphatase); PTPL1"
PTPN14	"PEZ; protein tyrosine phosphatase, non-receptor type 14"
PTPN17	"protein tyrosine phosphatase, non-receptor type 17"
PTPN2	"Hs.82829; PTPT; TCELLPTP; protein tyrosine phosphatase, non-receptor type 2"
PTPN21	"PTPD1; PTPRL10; protein tyrosine phosphatase, non-receptor type 21"
PTPN2P1	"PTPTP1; PTPN2P; protein tyrosine phosphatase, non-receptor type 2 (pseudogene 1)"
PTPN2P2	"protein tyrosine phosphatase, non-receptor type 2 (pseudogene 2)"
PTPN3	"Hs.644; PTPH1; protein tyrosine phosphatase, non-receptor type 3"
PTPN4	"PTPMEG; protein tyrosine phosphatase, non-receptor type 4 (megakaryocyte)"
PTPN5	"STEP; PTPSTEP; protein tyrosine phosphatase, non-receptor type 5 (striatum-enriched)"
PTPN6	"Hs.63489; HCP; HCPH; PTP-1C; protein tyrosine phosphatase, non-receptor type 6"

Name	Description of Enzyme
PTPN7	"Hs.73922; HEPTP; LC-PTP; protein tyrosine phosphatase, non-receptor type 7; Hs.35"
PTPN8	"protein tyrosine phosphatase, non-receptor type 8"
PTPN9	"Hs.78598; MEG2; protein tyrosine phosphatase, non-receptor type 9"
PTPNS1	"SIRP; SHPS1; MYD-1; SIRP-ALPHA-1; protein tyrosine phosphatase, non-receptor type substrate 1"
PTPRA	"Hs.26045; LRP; PTPA; HLPR; HPTPA; RPTPA; PTPRL2; protein tyrosine phosphatase, receptor type, alpha polypeptide"
PTPRB	"Hs.10623; PTPB; HPTPB; protein tyrosine phosphatase, receptor type, beta polypeptide"
PTPRC	"Hs.62399; LCA; CD45; T200; GP180; protein tyrosine phosphatase, receptor type, c polypeptide"
PTPRCAP	"protein tyrosine phosphatase, receptor type, c polypeptide-associated protein; LPAP; lymphocyte phosphatase-associated phosphoprotein"
PTPRD	"Hs.15320; HPTPD; protein tyrosine phosphatase, receptor type, delta polypeptide"
PTPRE	"HPTPE; protein tyrosine phosphatase, receptor type, epsilon polypeptide"
PTPRF	"Hs.75216; LAR; protein tyrosine phosphatase, receptor type, f polypeptide"
PTPRG	"D3S1249; Hs.89627; PTPG; HPTPG; RPTPG; protein tyrosine phosphatase, receptor type, gamma polypeptide"
PTPRH	"Hs.328; SAP-1; protein tyrosine phosphatase, receptor type, H"
PTPRJ	"protein tyrosine phosphatase, receptor type, J; DEP1; HPTPeta"
PTPRK	"protein tyrosine phosphatase, receptor type, K; R-PTP-kappa"
PTPRM	"Hs.7619; RPTPU; PTPRL1; protein tyrosine phosphatase, receptor type, mu polypeptide"
PTPRN	"IA-2; protein tyrosine phosphatase, receptor type, N"
PTPRN2	"protein tyrosine phosphatase, receptor type, N polypeptide 2; KIAA0387; A tyrosine phosphatase, phogrin/ICAAR (cf. Y08569/JC5062); IAR; ICAAR; PTPRP; phogrin; IA-2beta"
PTPRO	"protein tyrosine phosphatase, receptor type, O; PTPU2; GLEPP1; PTP-U2"
PTPRQ	"protein tyrosine phosphatase, receptor type, Q (NOTE: redefinition of symbol)"
PTPRR	"PTPRQ; protein tyrosine phosphatase, receptor type, R; protein tyrosine phosphatase, receptor type, Q; PTPBR7; PCPTP1; PTP-SL"
PTPRS	"protein tyrosine phosphatase, receptor type, sigma"
PTPRZ1	"PTPRZ; protein tyrosine phosphatase, receptor-type, zeta polypeptide 1; Hs.78867; PTPZ; HPTPZ; PTP18; RPTPB"
PTPRZ2	"protein tyrosine phosphatase, receptor-type, zeta polypeptide 2"
PTRF	polymerase I and transcript release factor
PTS	Hs.366; 6-pyruvoyltetrahydropterin synthase
PTSP1	PTSP1-PEN; 6-pyruvoyltetrahydropterin synthase pseudogene
PYCR1	Hs.79217; P5C; PYCR; pyrroline-5-carboxylate reductase 1
PYCS	pyrroline-5-carboxylate synthetase (glutamate gamma-semialdehyde synthetase); Hs.13048; P5CS; GSAS
PYGB	"Hs.75658; phosphorylase, glycogen; brain"
PYGBL	"phosphorylase, glycogen; brain-like"
PYGL	"phosphorylase, glycogen; liver (Hers disease, glycogen storage disease type VI); Hs.771"

Name	Description of Enzyme
PYGM	"phosphorylase, glycogen; muscle (McArdle syndrome, glycogen storage disease type V)"
PheHB	phenylalanyl-tRNA synthetase beta-subunit
QARS	glutamine-tRNA synthetase
QDPR	quinoid dihydropteridine reductase; Hs.75438; DHPR
QPRT	quinolinate phosphoribosyltransferase
RAB18	RAB18 small GTPase
RABGGTA	"Rab geranylgeranyl transferase, alpha subunit"
RABGGTB	"Rab geranylgeranyl transferase, beta subunit"
RACGAP1	MGCRACGAP; Rac GTPase activating protein 1
RAD53	CHK2; CDS1; HUCDS1; protein kinase Chk2; checkpoint kinase 2
RALDH2	retinaldehyde dehydrogenase 2
RANGAP1	Ran GTPase activating protein 1; Fug1
RAP1GA1	"Hs.75151; KREV-1; SMGP21; RAP1, GTPase activating protein 1"
RARS	arginyl-tRNA synthetase; Hs.74514
RASA1	RASA; Hs.758; RAS p21 protein activator (GTPase activating protein); GAP
RASA3	"GAPIII; RAS p21 protein activator (GTPase activating protein) 3 (Ins(1,3,4,5)P4-binding protein)"
RCE1	FACE-2; prenyl protein protease RCE1
RDH5	RDH1; retinol dehydrogenase 5 (11-cis and 9-cis); Hs.33730
RDHL]	retinol dehydrogenase homolog; RDHL
RDPA	Refsum disease with increased pipecolicacidemia
RECQL	Hs.1536; RecQ protein-like (DNA helicase Q1-like)
RET	"ret proto-oncogene (multiple endocrine neoplasia MEN2A, MEN2B and medullary thyroid carcinoma 1, Hirschsprung disease); Hs.6253; PTC; MTC1; MEN2A; HSCR1; MEN2B"
REV3L	"REV3 (yeast homolog)-like, catalytic subunit of DNA polymerase zeta; POLZ"
RHOK	Hs.103501; GRK1; rhodopsin kinase
RIPK1	receptor (TNFRSF)-interacting serine-threonine kinase 1; RIP; receptor (TNFRSF)-interacting serine-threonine kinase 1
RIPK2	RICK; RIP2; CARDIAK; receptor-interacting serine-threonine kinase 2
RMD1	rippling muscle disease 1
RMRP	RNA component of mitochondrial RNA processing endoribonuclease
RNAC	RNA cyclase homolog
RNAH	RNA helicase family
RNAHP	RNA helicase-related protein
RNASE1	"RNS1; ribonuclease, RNase A family, 1 (pancreatic); Hs.78224"
RNASE2	"RNS2; ribonuclease, RNase A family, 2 (liver, eosinophil-derived neurotoxin); EDN; Hs.728"
RNASE3	"RNS3; ribonuclease, RNase A family, 3 (eosinophil cationic protein); ECP; Hs.73839"
RNASE4	"ribonuclease, RNase A family, 4"
RNASE6	"RNS6; ribonuclease, RNase A family, k6"
RNASE6PL	ribonuclease 6 precursor
RNASEH1	ribonuclease H1; RNH1
RNASEHI	"ribonuclease HI, large subunit"

Name	Description of Enzyme
RNASEL	"RNS4; ribonuclease L (2',5'-oligoisoadenylate synthetase-dependent); Hs.10716; ribonuclease 4"
RNGTT	RNA guanylyltransferase and 5'-phosphatase; HCE; HCE1; hCAP
RNH	ribonuclease/angiogenin inhibitor; Hs.75108; RAI
RNMT	RNA (guanine-7-) methyltransferase
RNPEP	arginyl aminopeptidase (aminopeptidase B)
ROCK1	"Rho-associated, coiled-coil containing protein kinase 1; p160ROCK"
ROCK2	"KIAA0619; Rho-associated, coiled-coil containing protein kinase 2"
RODH	oxidative 3 alpha hydroxysteroid dehydrogenase; retinol dehydrogenase
RODH-4	microsomal NAD+-dependent retinol dehydrogenase 4
ROK1	ATP-dependent RNA helicase
RPA40	RPA39; RNA polymerase I subunit
RPC	RNA 3'-terminal phosphate cyclase
RPC155	polymerase (RNA) III (DNA directed) (155kD)
RPC32	polymerase (RNA) III (DNA directed) (32kD)
RPC39	polymerase (RNA) III (DNA directed) (39kD)
RPC62	polymerase (RNA) III (DNA directed) (62kD)
RPE	ribulose-5-phosphate-3-epimerase
RPGR	RP3; CRD; retinitis pigmentosa 3 (X-linked recessive); Retinitis pigmentosa GTPase regulator
RPIA	RPI; ribose 5-phosphate isomerase A (ribose 5-phosphate epimerase)
RPL17L1	"ribosomal protein L17-like 1, G1-phase expressed"
RPL7AL1	"ribosomal protein L7A-like 1, G1-phase expressed"
RPP14	ribonuclease P (14kD)
RPP30	ribonuclease P (30kD)
RPP38	ribonuclease P (38kD)
RPP40	"ribonuclease P, 40kD subunit"
RPS17L3	"ribosomal protein S17-like 3, G1-phase expressed"
RPS3L1	"ribosomal protein S3-like 1, G1-phase expressed"
RPS6KA1	"ribosomal protein S6 kinase, 90kD, polypeptide 1; RSK; HU-1; RSK1"
RPS6KA2	"ribosomal protein S6 kinase, 90kD, polypeptide 2; Hs.2079; RSK; HU-2; RSK3"
RPS6KA3	"ribosomal protein S6 kinase, 90kD, polypeptide 3; RSK; HU-2; RSK2; HU-3"
RPS6KA4	"ribosomal protein S6 kinase, 90kD, polypeptide 4; MSK2; RSK-B; ribosomal protein S6 kinase, 90kD, polypeptide 4"
RPS6KA5	"ribosomal protein S6 kinase, 90kD, polypeptide 5; MSK1; RLPK; MSPK1; ribosomal protein S6 kinase, 90kD, polypeptide 5"
RPS6KB1	"ribosomal protein S6 kinase, 70kD, polypeptide 1"
RPS6KB2	"ribosomal protein S6 kinase, 70kD, polypeptide 2"
RPS6KB3	"ribosomal protein S6 kinase, 70kD, polypeptide 3"
RRM1	ribonucleotide reductase M1 polypeptide
RRM2	Hs.75319; ribonucleotide reductase M2 polypeptide
RRM2P1	ribonucleotide reductase M2 polypeptide pseudogene 1
RRM2P2	ribonucleotide reductase M2 polypeptide pseudogene 2
RRM2P3	ribonucleotide reductase M2 polypeptide pseudogene 3
RRM2P4	ribonucleotide reductase M2 polypeptide pseudogene 4

Name	Description of Enzyme
RRP4	"homolog of Yeast RRP4 (ribosomal RNA processing 4), 3'-5'-exoribonuclease"
RYK	D3S3195; Hs.79350; RYK receptor-like tyrosine kinase
RYKL1	RYK receptor-like tyrosine kinase-like 1
RYR1	MHS1; ryanodine receptor 1 (skeletal); RYR; MHS; malignant hyperthermia susceptibility 1; sarcoplasmic reticulum calcium release gene
S1P	"site-1 protease (subtilisin-like, sterol-regulated, cleaves sterol regulatory element binding proteins)"
SARDH	DMGDHL1; sarcosine dehydrogenase; dimethylglycine dehydrogenase-like 1; SAR; SARD
SARS	SERS; seryl-tRNA synthetase
SAT	spermidine/spermine N1-acetyltransferase; Hs.28491; SSAT
SC4MOL	sterol-C4-methyl oxidase-like; DESP4; ERG25
SC4MOP	sterol-C4-methyl oxidase pseudogene; DESP4P1
SC5DL	"sterol-C5-desaturase (fungal ERG3, delta-5-desaturase)-like"
SCAD-SRL	SDR-SRL; peroxisomal short-chain alcohol dehydrogenase
SCCA2	squamous cell carcinoma antigen 2 (leupin); PI11; Protease Inhibitor(leucine-serpin)
SCD	stearoyl-CoA desaturase (delta-9-desaturase)
SCDP	stearoyl-CoA desaturase (delta-9-desaturase) pseudogene
SCN4A	"HYKPP; HYPP; hyperkalemic periodic paralysis (Gamstorp disease, adynamia episdica hereditaria); sodium channel, voltage-gated, type IV, alpha polypeptide"
SCN8A	"MED; sodium channel, voltage-gated, type VIII, alpha polypeptide; motor endplate disease"
SCO1	"SCOD1; SCO (cytochrome oxidase deficient, yeast) homolog 1"
SCO2	"SCO1L; SCO (cytochrome oxidase deficient, yeast) homolog 2"
SDHA	"SDH2; succinate dehydrogenase complex, subunit A, flavoprotein (Fp); Hs.469; FP"
SDHB	"SDH1; succinate dehydrogenase complex, subunit B, iron sulfur (IP); Hs.64; IP; SDH"
SDHC	"succinate dehydrogenase complex, subunit C, integral membrane protein, 15kD"
SDHD	"PGL1; succinate dehydrogenase complex, subunit D, integral membrane protein; paraganglioma or familial glomus tumors 1; PGL"
SDR1	short-chain dehydrogenase/reductase 1; RSDR1
SDS	serine dehydratase; Hs.76751; L-SERINE DEHYDRATASE; SDH
SEL	SEL-PEN; Selenophosphate synthetase
SETMAR	SET domain and mariner transposase fusion gene
SGK	serum/glucocorticoid regulated kinase; SGK1
SGK2	serum/glucocorticoid regulated kinase 2; H-SGK2
SGKL	SGK2; serum/glucocorticoid regulated kinase-like; SGK3
SGPL1	SPL; sphingosine-1-phosphate lyase 1
SGSH	N-sulfoglucosamine sulfohydrolase (sulfamidase); HSS
SH2D1A	"LYP; SH2 domain protein 1A, Duncan's disease (lymphoproliferative syndrome); XLP; IMD5; MTCP1; lymphoproliferative syndrome; SAP; DSHP; EBVS; XLPD; Duncan disease"

Name	Description of Enzyme
SHMT1	serine hydroxymethyltransferase 1 (soluble); Hs.8889; CSHMT; cytoplasmic serine hydroxymethyltransferase
SHMT1P	serine hydroxymethyltransferase 1 (soluble) pseudogene
SHMT2	SHMT; serine hydroxymethyltransferase 2 (mitochondrial)
SI	Hs.2996; sucrase-isomaltase
SIASD	SD; sialic acid storage disease; Salla Disease
SIAT1	"Hs.2554; sialyltransferase 1 (beta-galactoside alpha-2,6-sialytransferase)"
SIAT2	sialyltransferase 2 (monosialoganglioside sialyltransferase)
SIAT3	"SIAT3-PEN; sialyltransferase 3 (Gal beta 1,3 (4) Glc NAc Alpha 2,3-sialyltransferase); ST3N"
SIAT4A	"Hs.60617; sialyltransferase 4A (beta-galactosidase alpha-2,3-sialytransferase)"
SIAT4B	"sialyltransferase 4B (beta-galactosidase alpha-2,3-sialytransferase)"
SIAT4C	"CGS23; SIAT4; NANTA3; sialyltransferase 4C (beta-galactosidase alpha-2,3-sialytransferase)"
SIAT5	"STZ; SAT3; sialyltransferase 5 (galactosyldiacylglycerol alpha 2,3-sialyltransferase)"
SIAT6	"sialyltransferase 6 (N-acetyllacosaminide alpha 2,3-sialyltransferase)"
SIAT7	"sialyltransferase 7 ((alpha-N-acetylneuraminyl-2,3-beta-galactosyl-1,3)-N-acetyl galactosaminide alpha-2,6-sialyltransferase)"
SIAT8A	"SIAT8; Hs.82527; sialyltransferase 8 (alpha-N-acetylneuraminate: alpha-2,8-sialytransferase, GD3 synthase)"
SIAT8B	"STX; ST8SIA-II; sialyltransferase 8 (alpha-2, 8-sialytransferase) B"
SIAT8D	PST; polysialyltransferase
SIAT9	"ST3GALV; SIATGM3S; sialyltransferase 9 (CMP-NeuAc:lactosylceramide alpha-2,3-sialyltransferase; GM3 synthase)"
SIATL1	sialyltransferase-like 1
SIP2-28	CIB; KIP; calcium and integring binding protein (DNA-dependent protein kinase interacting protein)
SKAP55	src kinase-associated phosphoprotein of 55 kDa
SKP1A	S-phase kinase-associated protein 1A (p19A)
SKP1B	S-phase kinase-associated protein 1B (p19B)
SKP2	S-phase kinase-associated protein 2 (p45)
SLC23A1	"SVCT1; YSPL3; solute carrier family 23 (nucleobase transporters), member 1"
SLC25A16	GDA; ML7; solute carrier family 25 (mitochondrial carrier; Graves disease autoantigen) member 16
SLC25A20	"CACT; solute carrier family 25 (carnitine/acylcarnitine translocase), member 20; carnitine/acylcarnitine translocase; CAC"
SLC25A20P	"CACTP; solute carrier family 25 (carnitine/acylcarnitine translocase), member 20 pseudogene; carnitine/acylcarnitine translocase pseudogene"
SLK	"SNF1 (sucrose nonfermenting, yeast, homolog)-like kinase"
SLPI	secretory leukocyte protease inhibitor (antileukoproteinase); HUSI-I
SMA@	"SMA; spinal muscular atrophy (Werdnig-Hoffmann disease, Kugelberg-Welander disease)"
SMARCA3	"SNF2L3; SNF2 (sucrose nonfermenting, yeast, homolog)-like 3; SWI/SNF related, matrix associated, actin dependent regulator of chromatin, subfamily a, member 3; HLTF; HIP116; helicase-like transcription factor"

Name	Description of Enzyme
SMARCB1	"SNF5L1; SWI/SNF related, matrix associated, actin dependent regulator of chromatin, subfamily b, member 1; INI1; SNF5 (sucrose nonfermenting, yeast, homolog)-like 1 (integrase interactor 1); Snr1; BAF47; hSNFS; Sfh1p"
SMPD1	"sphingomyelin phosphodiesterase 1, acid lysosomal (acid sphingomyelinase); Hs.77813; Niemann-Pick disease"
SMPD2	"sphingomyelin phosphodiesterase 2, neutral membrane (neutral sphingomyelinase); nSMase"
SMS	spermine synthase; SpS
SNCA	"PARK1; synuclein, alpha (non A4 component of amyloid precursor); Parkinson disease, familial 1; Hs.76930; NACP; PD1"
SNK	serum-inducible kinase
SOAT1	SOAT; Hs.172; STAT; ACAT; sterol O-acyltransferase (acyl-Coenzyme A: cholesterol acyltransferase); ACAT-1
SOAT2	sterol O-acyltransferase 2; ACAT2; ARGP2; sterol O-acyltransferase 2
SOD1	"superoxide dismutase 1, soluble (amyotrophic lateral sclerosis 1 (adult)); Hs.75428; ALS; ALS1"
SOD2	"Hs.73830; superoxide dismutase 2, mitochondrial"
SOD3	"Hs.2420; superoxide dismutase 3, extracellular"
SORD	Hs.878; sorbitol dehydrogenase
SP-22	thioreductase-dependent peroxide reductase SP-22
SPAM1	"sperm adhesion molecule 1 (PH-20 hyaluronidase, zona pellucida binding); PH-20; HYAL3"
SPC18	signal peptidase complex (18kD)
SPHAR	s-phase response gene
SPHK1	sphingosine kinase 1
SPINK1	"Hs.46262; serine protease inhibitor, Kazal type 1"
SPINK2	"HUSI-II; serine protease inhibitor, Kazal type 2 (acrosin-trypsin inhibitor)"
SPINT1	"serine protease inhibitor, Kunitz type 1"
SPINT2	"KOP; HAI-2; serine protease inhibitor, Kunitz type, 2"
SPINT3	"HKIB9; serine protease inhibitor, Kunitz type, 3"
SPR	"sepiapterin reductase (7,8-dihydrobiopterin:NADP+ oxidoreductase)"
SPS2	selenophosphate synthetase 2
SPTI	LCB1; serine palmitoyltransferase subunit I
SPUVE	"serine protease, umbilical endothelium"
SQLE	squalene epoxidase
SRD5A1	"steroid-5-alpha-reductase, alpha polypeptide 1 (3-oxo-5 alpha-steroid delta 4-dehydrogenase alpha 1); Hs.552"
SRD5A2	"steroid-5-alpha-reductase, alpha polypeptide 2 (3-oxo-5 alpha-steroid delta 4-dehydrogenase alpha 2); Hs.1989"
SRD5AP1	"steroid-5-alpha-reductase, alpha polypeptide pseudogene 1 (3-oxo-5 alpha-steroid delta 4-dehydrogenase alpha pseudogene)"
SRD5BP1	"steroid-5-beta-reductase, beta polypeptide pseudogene 1"
SRM	Hs.76244; SRML1; spermidine synthase
SRML2	spermidine synthase-like 2
SRMS	SRM; src-related kinase lacking C-terminal regulatory tyrosine and N-terminal myristylation sites
SRPK1	SFRS protein kinase 1; SFRSK1

Name	Description of Enzyme
SRPK2	SFRS protein kinase 2; SFRSK2
ST3GALVI	"alpha2,3-sialyltransferase"
STAT3	signal transducer and activator of transcription 3 (acute-phase response factor); Hs.1618; APRF
STE	"sulfotransferase, estrogen-preferring; EST"
STGD2	Stargardt disease 2 (autosomal dominant)
STGD3	Stargardt disease 3 (autosomal dominant)
STGD4	Stargardt disease 4 (autosomal dominant)
STHM	sialyltransferase
STK10	serine/threonine kinase 10; LOK
STK11	serine/threonine kinase 11 (Peutz-Jeghers syndrome); PJS; LKB1
STK12	AIK2; ARK2; AIM-1; serine/threonine kinase 12
STK13	serine/threonine kinase 13 (aurora/IPL1-like)
STK14A	serine/threonine kinase 14 alpha; p70S6k
STK15	serine/threonine kinase 15; BTAK; serine/threonine kinase 15
STK16	MPSK; PKL12; serine/threonine kinase 16
STK17A	DRAK1; serine/threonine kinase 17a (apoptosis-inducing)
STK17B	DRAK2; serine/threonine kinase 17b (apoptosis-inducing)
STK18	serine/threonine kinase 18
STK19	serine/threonine kinase 19; D6S974E; D6S60; D6S60E; RP1; G11
STK2	Hs.1087; serine/threonine kinase 2
STK3	"serine/threonine kinase 3 (Ste20, yeast homolog); MST2; KRS1"
STK4	"serine/threonine kinase 4 (Ste20, yeast homolog); MST1; KRS2"
STK6	serine/threonine kinase 6; aurora IPL1-like kinase; BTAK; AIK
STK6P	serine/threonine kinase 6 pseudogene; STK6P1
STK9	serine/threonine kinase 9
STS	"ARSC1; ARSC; Hs.79876; arylsulfatase C, isozyme S; steroid sulfatase (microsomal)"
STSP	steroid sulfatase (microsomal) pseudogene
SUCLA2	"succinate-CoA ligase, ADP-forming, beta subunit"
SUCLG1	"SUCLA1; succinate-CoA ligase, GDP-forming, alpha subunit"
SUCLG2	"succinate-CoA ligase, GDP-forming, beta subunit"
SULT	sulfotransferase
SULT1A1	"STP1; sulfotransferase family 1A, phenol-preferring, member 1; STP; P-PST; sulfotransferase, phenol-preferring 1"
SULT1A2	"STP2; sulfotransferase family 1A, phenol-preferring, member 2; sulfotransferase, phenol-preferring 2; HAST4"
SULT1A3	"STM; sulfotransferase family 1A, phenol-preferring, member 3; TL-PST; sulfotransferase, monoamine-preferring"
SULT1C1	sulfotransferase 1C1
SULT1C2	SULT1C sulfotransferase
SULT2A1	"STD; sulfotransferase family 2A, dehydroepiandrosterone (DHEA)-preferring, member 1; Hs.81884; DHEA-ST; sulfotransferase, dehydroepiandrosterone (DHEA) -preferring"
SULT2B1	"sulfotransferase family 2B, member 1; HSST2"
SUOX	sulfite oxidase

Name	Description of Enzyme
SURB7	"SRB7; SRB7 (suppressor of RNA polymerase B, yeast) homolog"
SYK	Hs.74101; spleen tyrosine kinase
SYNGAP	"synaptic Ras GTPase activating protein, 135-kD, rat, homolog of"
SYNJ1	synaptojanin 1; inositol 5'-phosphatase (synaptojanin 1); INPP5G
SYNJ2	synaptojanin 2; inositol phosphate 5'-phosphatase 2 (synaptojanin 2); INPP5H
TACTILE	"T cell activation, increased late expression"
TADA3L	"ADA3; transcriptional adaptor 2 (ADA2, yeast homolog)-3 like (PCAF histone acetylase complex)"
TAF1A	"SL1; TAFI48; TATA box binding protein (TBP)-associated factor, RNA polymerase I, A, 48kD"
TAF1B	"SL1; TAFI63; TATA box binding protein (TBP)-associated factor, RNA polymerase I, B, 63kD"
TAF1C	"SL1; TAFI95; TAFI110; TATA box binding protein (TBP)-associated factor, RNA polymerase I, C, 110kD"
TAF2A	"CCG1; BA2R; TATA box binding protein (TBP)-associated factor, RNA polymerase II, A, 250kD; CCGS; NSCL2; TAFII250; BALB/c 3T3 ts2 temperature sensitivity complementing; cell cycle, G1 phase defect, (transcription factor TFIID p250 polypeptide)"
TAF2B	"TATA box binding protein (TBP)-associated factor, RNA polymerase II, B, 150kD; TAFII150"
TAF2C1	"TAF2C; TATA box binding protein (TBP)-associated factor, RNA polymerase II, C1, 130kD; TAFII130; TAFII135"
TAF2C2	"TATA box binding protein (TBP)-associated factor, RNA polymerase II, C2, 105kD; TAFII105"
TAF2D	"TATA box binding protein (TBP)-associated factor, RNA polymerase II, D, 100kD; TAFII100"
TAF2E	"TATA box binding protein (TBP)-associated factor, RNA polymerase II, E, 70/85kD; TAFII70; TAFII85"
TAF2F	"TAFII55; TATA box binding protein (TBP)-associated factor, RNA polymerase II, F, 55kD"
TAF2G	"TATA box binding protein (TBP)-associated factor, RNA polymerase II, G, 32kD; TAFII31; TAFII32"
TAF2H	"TATA box binding protein (TBP)-associated factor, RNA polymerase II, H, 30kD; TAF2A; TAFII30"
TAF2I	"TATA box binding protein (TBP)-associated factor, RNA polymerase II, I, 28kD; TAFII28"
TAF2J	"TATA box binding protein (TBP)-associated factor, RNA polymerase II, J, 20kD; TAFII20"
TAF2K	"TATA box binding protein (TBP)-associated factor, RNA polymerase II, K, 18kD; TAFII18"
TAF3A	"TAFIII134; TATA box binding protein (TBP)-associated factor, RNA polymerase III, A, 134kD"
TAF3B	"TAFIII120; TATA box binding protein (TBP)-associated factor, RNA polymerase III, B, 120kD"
TAF3D	"TAFIII80; TATA box binding protein (TBP)-associated factor, RNA polymerase III, D, 80kD"
TALDO1	transaldolase 1
TALDOP1	TALDO; transaldolase pseudogene 1; Hs.77290; TAL-H

Name	Description of Enzyme
TAO1	KIAA0881; thousand and one amino acid protein kinase
TARS	Hs.84131; threonyl-tRNA synthetase
TAT	Hs.2999; tyrosine aminotransferase
TBXAS1	"thromboxane A synthase 1 (platelet, cytochrome P450, subfamily V); CYP5A1; CYP5"
TDD	"testicular 17,20-desmolase deficiency"
TDG	thymine-DNA glycosylase
TDO2	"tryptophan 2,3-dioxygenase"
TDO2L1	"tryptophan 2,3-dioxygenase-like 1"
TDPGD	"dTDP-D-glucose 4,6-dehydratase"
TDPX1	"thioredoxin-dependent peroxide reductase 1 (thiol-specific antioxidant 1, natural killer-enhancing factor B); PRP; NKEFB"
TDPX2	"PAGB; thioredoxin-dependent peroxide reductase 2 (thiol-specific antioxidant 2, proliferation-associated gene B)"
TEC	tec protein tyrosine kinase; Hs.89656; PSCTK4
TEK	"VMCM; TEK tyrosine kinase, endothelial (venous malformations, multiple cutaneous and mucosal); TEK tyrosine kinase, endothelial; TIE2; VMCM1; venous malformations, multiple cutaneous and mucosal"
TEP1	telomerase-associated protein 1; telomerase protein component 1; TP1; TLP1
TERC	telomerase RNA component; hTR
TERT	telomerase reverse transcriptase; TRT; TP2; TCS1; hEST2
TESK1	testis-specific kinase 1
TESK2	testis-specific kinase 2
TGFBR1	"ALK-5; ACVRLK4; transforming growth factor, beta receptor I (activin A receptor type II-like kinase, 53kD)"
TGM1	"transglutaminase 1 (K polypeptide epidermal type I, protein-glutamine-gamma-glutamyltransferase); Hs.22; ICR2; TGASE; ichthyosis congenita II, non-erythromatous lamellar ichthyosis"
TGM2	"transglutaminase 2 (C polypeptide, protein-glutamine-gamma-glutamyltransferase)"
TGM3	"Hs.2022; transglutaminase 3 (E polypeptide, protein-glutamine-gamma-glutamyltransferase)"
TGM4	Hs.2387; transglutaminase 4 (prostate)
TGM5	TGX; TGMX; transglutaminase 5
TH	Hs.89849; tyrosine hydroxylase; Hs.2031; Hs.89780
THOP1	thimet oligopeptidase 1
THOP2	thimet oligopeptidase 2
TIE	Hs.78824; JTK14; tyrosine kinase with immunoglobulin and epidermal growth factor homology domains; TIE1
TIM17	TIM17A; preprotein translocase
TIM17B	JM3; inner mitochondrial membrane preprotein translocase
TIM44	mitochondrial inner membrane translocase
TIMM8A	"DFN1; translocase of inner mitochondrial membrane 8 (yeast) homolog A; deafness, X-linked 1, progressive; DXS1274E; DDP; MTS; deafness 1, progressive; Mohr-Tranebjaerg syndrome; deafness/dystonia peptide"
TIMP1	"Hs.1417; EPO; TIMP; CLGI; tissue inhibitor of metalloproteinase 1 (erythroid potentiating activity, collagenase inhibitor)"

Name	Description of Enzyme
TIMP2	Hs.1795; tissue inhibitor of metalloproteinase 2
TIMP3	"SFD; tissue inhibitor of metalloproteinase 3 (Sorsby fundus dystrophy, pseudoinflammatory)"
TIMP4	tissue inhibitor of metalloproteinase 4
TK1	"thymidine kinase 1, soluble; Hs.2033"
TK2	"thymidine kinase 2, mitochondrial"
TKT	Hs.89643; transketolase (Wernicke-Korsakoff syndrome)
TKTL1	transketolase-like 1; TKR; transketolase-related gene; TKR-PEN; TKT; TKT2
TLK2	tousled-like kinase 2; serine/threonine kinase; PKU-alpha
TLSP	"protease, serine, trypsin-like"
TMPRSS2	"transmembrane protease, serine 2; PRSS10"
TMPRSS3	"transmembrane protease, serine 3"
TNK1	"tyrosine kinase, non-receptor, 1"
TNKS	"tankyrase, TRF1-interacting ankyrin-related ADP-ribose polymerase; PARPL; TIN1; TINF1"
TOM34	HTOM34P; outer mitochondrial membrane translocase (34kD)
TOP1	Hs.317; topoisomerase (DNA) I
TOP1P1	topoisomerase (DNA) I pseudogene 1
TOP1P2	topoisomerase (DNA) I pseudogene 2
TOP2A	Hs.3378; TOP2; topoisomerase (DNA) II alpha (170kD)
TOP2B	Hs.75248; topoisomerase (DNA) II beta (180kD)
TOP3	topoisomerase (DNA) III
TOP3B	topoisomerase (DNA) III beta
TPH	TPRH; tryptophan hydroxylase (tryptophan 5-monooxygenase)
TPI1	triosephosphate isomerase 1
TPMT	thiopurine S-methyltransferase; Hs.85291; Hs.74021
TPO	thyroid peroxidase; Hs.2041
TPP2	Hs.1117; tripeptidyl peptidase II
TPS1	"Hs.73834; tryptase, alpha"
TPS2	"Hs.99917; tryptase, beta (tryptase II); Hs.1127; Hs.96059"
TPST1	tyrosylprotein sulfotransferase 1
TPST2	tyrosylprotein sulfotransferase 2
TPTE	transmembrane phosphatase with tensin homology
TR	TR3; TRXR2; thioredoxin reductase beta
TRAD	DUET; serine/threonine kinase with Dbl- and pleckstrin homology domains
TREH	trehalase (brush-border membrane glycoprotein); TRE; TREA
TREX1	"three prime repair exonuclease 1; deoxyribonuclease III, dnaQ/mutD (E. coli)-like; DRN3"
TREX2	Three prime repair exonuclease 2
TRF4	LAK-1; TRF4-1; topoisomerase-related function protein 4
TST	Hs.74097; thiosulfate sulfurtransferase (rhodanese)
TTF1	"transcription termination factor, RNA polymerase I; Hs.89853"
TTF2	"transcription termination factor, RNA polymerase II; HUF2; transcription termination factor, RNA polymerase II"
TTK	Hs.2052; TTK protein kinase
TXK	TXK tyrosine kinase; Hs.29877; TKL; PSCTK5

Name	Description of Enzyme
TXNRD1	TXNR; thioredoxin reductase 1; Hs.13046
TYK2	Hs.75516; JTK1; tyrosine kinase 2
TYMS	Hs.82962; TS; thymidylate synthetase
TYP1	TYP1-PEN; threonine-tyrosine phosphatase 1
TYR	Hs.2053; OCAIA; tyrosinase (oculocutaneous albinism IA)
TYRL	tyrosinase-like
TYRO3	RSE; Tyro3 protein tyrosine kinase; Tyro3 protein tyrosine kinase (sea-related receptor tyrosine kinase); Hs.301; Dtk; Brt; Tif; Sky
TYRO3P	TYRO3P protein tyrosine kinase pseudogene
TYRO4	TYRO4 protein tyrosine kinase
TYROBP	DAP12; KARAP; TYRO protein tyrosine kinase binding protein
TYRP1	Hs.75219; CAS2; TYRP; tyrosinase-related protein 1
U5-200-KD	"U5 snRNP-specific protein, 200 kDa (DEXH RNA helicase family)"
UBE3A	"ubiquitin protein ligase E3A (human papilloma virus E6-associated protein, Angelman syndrome); E6-AP; EPVE6AP; AS; Angelman syndrome"
UBE3AP1	ubiquitin protein ligase E3A pseudogene 1
UBE3AP2	ubiquitin protein ligase E3A pseudogene 2
UBR1	"ubiquitin-protein ligase e3 component, N-recognin"
UBTF	"UBF; upstream binding transcription factor, RNA polymerase I"
UCHH2	ubiquitin carboxyl-terminal esterase H2 (ubiquitin thiolesterase)
UCHL1	ubiquitin carboxyl-terminal esterase L1 (ubiquitin thiolesterase)
UCHL2	ubiquitin carboxyl-terminal esterase L2 (ubiquitin thiolesterase)
UCHL3	ubiquitin carboxyl-terminal esterase L3 (ubiquitin thiolesterase)
UGCG	UDP-glucose ceramide glucosyltransferase
UGDH	UDP-glucose dehydrogenase
UGP1	UDP-glucose pyrophosphorylase 1
UGP2	UDP-glucose pyrophosphorylase 2
UGT1	UGT1A1; UDP glycosyltransferase 1; GNT1
UGT2A1	"UDP glycosyltransferase 2 family, polypeptide A1"
UGT2B	"UGT2; UGT2B@; UDP-glucuronosyltransferase 2 family, polypeptide B; UDP-glucuronosyltransferase 2 family, polypeptide B gene cluster"
UGT2B10	"UDP glycosyltransferase 2 family, polypeptide B10"
UGT2B11	"UDP glycosyltransferase 2 family, polypeptide B11"
UGT2B15	"UDP glycosyltransferase 2 family, polypeptide B15; UGT2B8"
UGT2B17	"UDP glycosyltransferase 2 family, polypeptide B17"
UGT2B4	"UDP glycosyltransferase 2 family, polypeptide B4; UGT2B11"
UGT2B7	"UDP glycosyltransferase 2 family, polypeptide B7; UGT2B9"
UGT8	CGT; UDP glycosyltransferase 8 (UDP-galactose ceramide galactosyl transferase); Hs.57700
ULK1	unc-51 (C. elegans)-like kinase 1
UMPH2	uridine 5'-monophosphate phosphohydrolase 2
UMPK	uridine monophosphate kinase
UMPS	Hs.2057; uridine monophosphate synthetase (orotate phosphoribosyl transferase and orotidine-5'-decarboxylase)
UNG	Hs.78853; DGU; UDG; uracil-DNA glycosylase; Hs.3041
UNG2	uracil-DNA glycosylase 2

Name	Description of Enzyme
UNGP1	UNGP1-PEN; uracil-DNA glycosylase pseudogene 1
UNGP2	UNGP2-PEN; uracil-DNA glycosylase pseudogene 2
UOX	urate oxidase
UP	uridine phosphorylase
UQCR	ubiquinol-cytochrome c reductase (6.4kD) subunit
UQCRB	ubiquinol-cytochrome c reductase binding protein; Hs.1926; UQBP; QP-C
UQCRBP1	ubiquinol-cytochrome c reductase binding protein pseudogene 1
UQCRBP2	ubiquinol-cytochrome c reductase binding protein pseudogene 2
UQCRC1	D3S3191; Hs.99878; ubiquinol-cytochrome c reductase core protein I; Hs.75164
UQCRC2	ubiquinol-cytochrome c reductase core protein II
UQCRFS1	"RIS1; ubiquinol-cytochrome c reductase, Rieske iron-sulfur polypeptide 1"
UQCRFSL1	"ubiquinol-cytochrome c reductase, Rieske iron-sulfur polypeptide-like 1"
UQCRH	ubiquinol-cytochrome c reductase hinge protein
UROD	Hs.78601; uroporphyrinogen decarboxylase
UROS	Hs.75593; uroporphyrinogen III synthase (congenital erythropoietic porphyria)
USP1	ubiquitin specific protease 1
USP11	UHX1; ubiquitin specific protease 11
USP13	ISOT-3; ubiquitin specific protease 13 (isopeptidase T-3)
USP14	TGT; ubiquitin specific protease 14 (tRNA-guanine transglycosylase)
USP15	KIAA0529; ubiquitin specific protease 15
USP16	UBP-M; ubiquitin specific protease 16; UBPM; UBP-M
USP18	ubiquitin specific protease 18
USP19	KIAA0891; ubiquitin specific protease 19
USP2	ubiquitin specific protease 2; UBP41
USP20	KIAA1003; ubiquitin specific protease 20
USP21	USP23; ubiquitin specific protease 21; USP16
USP25	ubiquitin specific protease 25; USP21
USP3	ubiquitin specific protease 3
USP4	"UNP; ubiquitin specific protease, proto-oncogene; Unph"
USP5	ubiquitin specific protease 5 (isopeptidase T); IsoT; ISOT-1
USP6	HRP1; ubiquitin specific protease 6 (Tre-2 oncogene); TRE-2; TRE17; hyperpolymorphic gene 1
USP7	ubiquitin specific protease 7 (herpes virus-associated); HAUSP; herpesvirus-associated ubiquitin-specific protease
USP9X	"ubiquitin specific protease 9, X chromosome (Drosophila fat facets related); DFFRX; Drosophila fat facets related X"
USP9Y	"ubiquitin specific protease 9, Y chromosome (Drosophila fat facets related); DFFRY; Drosophila fat facets related Y"
UST	uronyl 2-sulfotransferase
VAKTI	LETKI; LEKTI; serine proteinase inhibitor
VARS1	VARS; valyl-tRNA synthetase 1
VARS2	valyl-tRNA synthetase 2
VBCH	van Buchem disease; hyperostosis corticalis generalisata
VLCS-H2	very long-chain acyl-CoA synthetase homolog 2
VMD2	vitelliform macular dystrophy (Best disease)

Name	Description of Enzyme
VRK1	vaccinia related kinase 1
VRK2	vaccinia related kinase 2
VWFCP	von Willebrand factor-cleaving protease
WARS	IFI53; tryptophanyl-tRNA synthetase; interferon-induced protein 53; IFP53
WARS2	tryptophanyl tRNA synthetase 2 (mitochondrial)
WWP2	AIP2; Nedd-4-like ubiquitin-protein ligase
XBX1	"xylan 1,4-beta-xylosidase 1"
XDH	Hs.250; xanthine dehydrogenase
XPNPEP1	"XPNPEP; X-prolyl aminopeptidase (aminopeptidase P) 1, soluble"
XPNPEP2	"X-prolyl aminopeptidase (aminopeptidase P) 2, membrane-bound"
XPNPEPL	X-prolyl aminopeptidase (aminopeptidase P)-like; pepP
XRN2	5'-3' exoribonuclease 2
XWNPEP	X-tryptophanyl aminopeptidase (aminopeptidase W)
XYLB	xylulokinase (H. influenzae) homolog
YARS	YTS; YRS; TYRRS; tyrosyl-tRNA synthetase
YSK1	SOK1; sterile 20 (oxidant stress response kinase 1; yeast Sps1/Ste20-related kinase 1)
YVH1	S. cerevisiae YVH1 protein-tyrosine phosphatase ortholog
YWHAA	"tyrosine 3-monooxygenase/tryptophan 5-monooxygenase activation protein, alpha polypeptide"
YWHAB	"Hs.82140; tyrosine 3-monooxygenase/tryptophan 5-monooxygenase activation protein, beta polypeptide"
YWHAD	"tyrosine 3-monooxygenase/tryptophan 5-monooxygenase activation protein, delta polypeptide"
YWHAE	"tyrosine 3-monooxygenase/tryptophan 5-monooxygenase activation protein, epsilon polypeptide; 14-3-3 epsilon"
YWHAG	"tyrosine 3-monooxygenase/tryptophan 5-monooxygenase activation protein, gamma polypeptide"
YWHAH	"Hs.75544; YWHA1; tyrosine 3-monooxygenase/tryptophan 5-monooxygenase activation protein, eta polypeptide"
YWHAQ	"tyrosine 3-monooxygenase/tryptophan 5-monooxygenase activation protein, theta polypeptide; HS1; tyrosine 3-monooxygenase/tryptophan 5-monooxygenase activation protein, theta polypeptide"
YWHAZ	"Hs.75103; tyrosine 3-monooxygenase/tryptophan 5-monooxygenase activation protein, zeta polypeptide"
ZAP70	SRK; zeta-chain (TCR) associated protein kinase (70 kD); syk-related tyrosine kinase
ZMPSTE24	"STE24; STE24P; FACE-1; zinc metalloproteinase, STE24 (yeast, homolog)"
ZRK	"zona pellucida receptor tyrosine kinase, 95kD"
hMP1	metalloprotease 1 (pitrilysin family)

Alternatively, the target sequence may encode a nuclear protein such as a nucleic acid binding protein. Examples of nucleic acid binding proteins that may be utilized in the present invention are presented in Table III.

Table III

Name	DNA Binding Protein Description
ALRP	ankyrin-like repeat protein; CARP; C-193; cytokine inducible nuclear protein; cardiac ankyrin repeat protein
APEG1	"nuclear protein, marker for differentiated aortic smooth muscle and down-regulated with vascular injury"
APEX	APE; APEX nuclease (multifunctional DNA repair enzyme); REF1; HAP1; apurinic/apyrimidinic (abasic) endonuclease
ARNT	aryl hydrocarbon receptor nuclear translocator; Hs.47477; HIF1beta
ARNTL	aryl hydrocarbon receptor nuclear translocator-like; MOP3; JAP3; BMAL1
B4-2	proline-rich protein with nuclear targeting signal
BLZF1	JEM1; basic leucine zipper nuclear factor 1 (JEM-1)
C1D	nuclear DNA-binding protein
C1D	nuclear DNA-binding protein
CHD1	chromodomain helicase DNA binding protein 1
CHD1L	CHDL; CHD1L-PENDING; chromodomain helicase DNA binding protein 1-like
CHD2	chromodomain helicase DNA binding protein 2
CHD3	chromodomain helicase DNA binding protein 3; Mi-2a
CHD4	chromodomain helicase DNA binding protein 4; Mi-2b
DAP10	DNAX-activation protein 10
DDB1	Hs.74623; damage-specific DNA binding protein 1 (127kD)
DDB2	Hs.77602; damage-specific DNA binding protein 2 (48kD)
DDX9	"DEAD/H (Asp-Glu-Ala-Asp/His) box polypeptide 9 (RNA helicase A, nuclear DNA helicase II); NDHII"
DDX9	"DEAD/H (Asp-Glu-Ala-Asp/His) box polypeptide 9 (RNA helicase A, nuclear DNA helicase II); NDHII"
DDXL	"nuclear RNA helicase, DECD variant of DEAD box family"
DEK	DEK oncogene (DNA binding); D6S231E
DFFA	"DNA fragmentation factor, 45 kD, alpha subunit"
DFFB	"DNA fragmentation factor, 40 kD, beta polypeptide (caspase-activated DNase); DNA fragmentation factor, 40 kD, beta subunit; CAD; DFF2; CPAN; DFF40; DFF-40"
DMC1	"DMC1 (dosage suppressor of mck1, yeast homolog) meiosis-specific homologous recombination; DMC1H; disrupted meiotic cDNA 1 homolog; LIM15"
DNA2L	"DNA2 (DNA replication helicase, yeast, homolog)-like"
DNAH11	"DNAHC11; dynein, axonemal, heavy chain 11"
DNAH12	DHC3; HL19; HDHC3; HL-19; DNAHC3; DNAHC12; dynein heavy chain 12
DNASE2	"DNL2; deoxyribonuclease II, lysosomal; DNL; DNase II, lysosomal"
ENC1	"NRPB; nuclear restricted protein, BTB domain-like (brain); PIG10; NRP/B"
FBRNP	heterogeneous nuclear protein similar to rat helix destabilizing protein
GADD45A	DDIT1; Hs.80409; GADD45; DNA-damage-inducible transcript 1
GADD45G	"CR6; GADD45-GAMMA; growth arrest and DNA-damage-inducible, gamma"
GRLF1	GRF-1; glucocorticoid receptor DNA binding factor 1
HDGF	hepatoma-derived growth factor (high-mobility group protein 1-like); HMG1L2
HIRIP4	DNAJ; HIRA interacting protein 4 (dnaJ-like)

Name	DNA Binding Protein Description
HLJ1	DNAJW; DnaJ-like heat shock protein 40
HMG1	high-mobility group (nonhistone chromosomal) protein 1; HMG3; Hs.74570
HMG1L1	HMG1L7; high-mobility group (nonhistone chromosomal) protein 1-like 1
HMGCS1	Hs.21808; HMGCS; 3-hydroxy-3-methylglutaryl-Coenzyme A synthase 1 (soluble)
HMGIY	high-mobility group (nonhistone chromosomal) protein isoforms I and Y; Hs.64605; HMGI-Y; HMGI/Y
HNF3A	"hepatocyte nuclear factor 3, alpha"
HNF3B	"hepatocyte nuclear factor 3, beta"
HNF3G	"hepatocyte nuclear factor 3, gamma"
HNF4A	"TCF14; hepatic nuclear factor 4, alpha"
HNF4B	"hepatocyte nuclear factor 4, beta"
HNF4G	"hepatocyte nuclear factor 4, gamma"
HNF6	hepatocyte nuclear factor 6
HNF6A	"hepatocyte nuclear factor 6, alpha"
HRIHFB2122	putative nuclear protein
HSJ1	"heat shock protein, neuronal DNAJ-like, 1; HSPF3"
HSJ2	"heat shock protein, DNAJ-like 2; HSPF4; dj-2; hdj-2"
ID1	"Hs.75424; inhibitor of DNA binding 1, dominant negative helix-loop-helix protein"
ID2	"inhibitor of DNA binding 2, dominant negative helix-loop-helix protein; Hs.76667"
ID3	"Hs.76884; HEIR-1; inhibitor of DNA binding 3, dominant negative helix-loop-helix protein"
ID4	"Hs.34853; inhibitor of DNA binding 4, dominant negative helix-loop-helix protein"
INSL	Insulin-like DNA sequence
KIAA0765	HRIHFB2091; putative brain nuclearly-targeted protein
KIP2	DNA-dependent protein kinase catalytic subunit-interacting protein 2
LAF4	lymphoid nuclear protein 4
LHFP	lipoma HMGIC fusion partner
LHFPL1	lipoma HMGIC fusion partner-like 1
LHFPL3	lipoma HMGIC fusion partner-like 3
LHFPL4	lipoma HMGIC fusion partner-like 4
LIG1	"Hs.1770; ligase I, DNA, ATP-dependent"
LIG2	"ligase II, DNA, ATP-dependent"
LIG3	"Hs.100299; ligase III, DNA, ATP-dependent"
LIG4	"ligase IV, DNA, ATP-dependent"
LPSA	"Oncogene liposarcoma (DNA segment, single copy, expressed, probes"
LXR	"orphan nuclear hormone receptor, retinoid response"
M96	putative DNA binding protein
MERR	metalloregulatory DNA-binding protein
MGMT	O-6-methylguanine-DNA methyltransferase; Hs.1384
MNDA	Hs.3197; myeloid cell nuclear differentiation antigen
MPG	Hs.79396; MDG; N-methylpurine-DNA glycosylase
MRJ	MRJ gene for a member of the DNAJ protein family

Name	DNA Binding Protein Description
NAGR1	N-acetylglucosamine receptor 1 (thyroid); heterogenous nuclear ribonucleoprotein M4
NASP	Hs.68875; nuclear autoantigenic sperm protein (histone-binding)
NCBP	"Hs.89750; nuclear cap binding protein, 80kD; Hs.89563"
NCOA1	nuclear receptor coactivator 1; SRC1; steroid receptor coactivator 1; NCoA-1; F-SRC-1
NCOA3	nuclear receptor coactivator 3; AIB1; ACTR; RAC3; p/CIP; CAGH16; TNRC16; TRAM-1; amplified in breast cancer 1
NCOA4	nuclear receptor coactivator 4; RFG; ELE1; ARA70
NCOR1	nuclear receptor co-repressor 1; N-CoR; TRAC1; hN-CoR; KIAA1047; hCIT529I10
NCOR2	nuclear receptor co-repressor 2; SMRT; CTG26; SMRTE; TNRC14; TRAC-1
NCYM	DNA-binding transcriptional activator
NDP52	nuclear domain 10 protein
NDR	"NDR-LSB; serine/threonine kinase, nuclear Dfnb2-related (Drosophila) homolog"
NFAT5	nuclear factor of activated T-cells 5; TONEBP; KIAA0827
NFATC1	"nuclear factor of activated T-cells, cytoplasmic 1; NF-ATC"
NFATC2	"NF-ATP; nuclear factor of activated T-cells, cytoplasmic 2"
NFATC3	"NFAT4; NFATX; nuclear factor of activated T-cells, cytoplasmic 3"
NFATC4	"NFAT3; nuclear factor of activated T-cells, cytoplasmic 4"
NFATC5	"nuclear factor of activated T-cells, cytoplasmic 5"
NFE2	"NF-E2; nuclear factor (erythroid-derived 2), 45kD"
NFE2L1	nuclear factor (erythroid-derived 2)-like 1; NRF1; LCR-F1
NFE2L2	NRF2; nuclear factor (erythroid-derived 2)-like 2
NFE2L3	NRF3; nuclear factor (erythroid-derived 2)-like 3
NFIA	KIAA1439; NFI-L; nuclear factor I/A
NFIB	NFI-RED; nuclear factor I/B
NFIC	NFI; CTF; NF-I; nuclear factor I/C (CCAAT-binding transcription factor)
NFIL3	"IL3BP1; nuclear factor, interleukin 3 regulated; E4BP4; NFIL3A; NF-IL3A"
NFIX	Hs.99929; nuclear factor I/X (CCAAT-binding transcription factor)
NFIXL1	nuclear factor I/X-like 1
NFIXL2	nuclear factor I/X-like 2
NFIXL3	nuclear factor I/X-like 3
NFIXL4	NFIX; nuclear factor I/X-like 4
NFIXL5	nuclear factor I/X-like 5
NFKB1	Hs.83428; KBF1; nuclear factor of kappa light polypeptide gene enhancer in B-cells 1 (p105)
NFKB2	Hs.73090; LYT-10; nuclear factor of kappa light polypeptide gene enhancer in B-cells 2 (p49/p100)
NFKBIA	"NFKBI; nuclear factor of kappa light polypeptide gene enhancer in B-cells inhibitor, alpha; IKBA; MAD-3"
NFKBIB	"nuclear factor of kappa light polypeptide gene enhancer in B-cells inhibitor, beta; IKBB; TRIP9"
NFKBIE	"nuclear factor of kappa light polypeptide gene enhancer in B-cells inhibitor, epsilon; IKBE"

Name	DNA Binding Protein Description
NFKBIL1	IKBL; NFKBIL; nuclear factor of kappa light polypeptide gene enhancer in B-cells inhibitor-like 1
NFKBIL2	IKBR; nuclear factor of kappa light polypeptide gene enhancer in B-cells inhibitor-like 2
NFRKB	nuclear factor related to kappa B binding protein
NFX1	"nuclear transcription factor, X-box binding 1"
NFYA	"nuclear transcription factor Y, alpha; Hs.797; HAP2; CBF-A"
NFYB	"nuclear transcription factor Y, beta; CBF-B"
NFYC	"nuclear transcription factor Y, gamma; CBF-C"
NIP1	NIP1-PEN; Nuclear cap binding protein(NCBP) interacting protein-1
NIP1L	"nip1 (nuclear import protein, S cerevisiae)-like"
NLVCF	nuclear localization signal deleted in velocardiofacial syndrome
NR1D1	"EAR-1; THRAL; REV-ERBAALPHA; nuclear receptor subfamily 1, group D, member 1"
NR1D2	"RVR; BD73; HZF2; EAR-1R; nuclear receptor subfamily 1, group D, member 2"
NR1H2	UNR; ubiquitously-expressed nuclear receptor
NR1H3	"LXRA; LXR-A; RLD-1; NR1H3-PENDING; nuclear receptor subfamily 1, group H, member 3"
NR1H4	"FXR; HRR1; RIP14; NR1H4-PENDING; nuclear receptor subfamily 1, group H, member 4"
NR1I2	"nuclear receptor subfamily 1, group I, member 2; PXR; SXR; SAR; BXR; ONR1; PAR2; nuclear receptor subfamily 1, group I, member 2"
NR1I3	"CAR; MB67; NR1I3-PENDING; nuclear receptor subfamily 1, group I, member 3"
NR1I4	"CAR2; nuclear receptor subfamily 1, group I, member 4"
NR2C1	TR2; TR2 nuclear hormone receptor; TR2
NR2C2	"TR4; nuclear receptor subfamily 2, group C, member 2; TR4 nuclear hormone receptor; TAK1"
NR2E3	"PNR; nuclear receptor subfamily 2, group E, member 3"
NR3C1	"GRL; nuclear receptor subfamily 3, group C, member 1; Hs.75772; glucocorticoid receptor; GR; Hs.49281"
NR4A1	"HMR; nuclear receptor subfamily 4, group A, member 1; hormone receptor (growth factor-inducible nuclear protein N10); TR3; Hs.1119; GFRP1; N10; NAK1; NAK-1; NGFIB; nur77"
NR4A2	NURR1; nuclear receptor related 1 (transcriptionally inducible); TINUR; NOT
NR4A3	"nuclear receptor subfamily 4, group A, member 3; CHN; CSMF; NOR1; MINOR"
NR6A1	GCNF; germ cell nuclear factor; RTR; GCNF1
NRB	"NRB-PEN; nuclear RNA-binding protein, 54kDa"
NRF1	nuclear respiratory factor 1
NRIP1	nuclear receptor interacting protein 1; RIP140
NUMA1	NUMA; nuclear mitotic apparatus protein 1
NVL	nuclear VCP-like
OGG1	8-oxoguanine DNA glycosylase

Name	DNA Binding Protein Description
PCBD	Hs.3192; PCD; DCOH; 6-pyruvoyl-tetrahydropterin synthase/dimerization cofactor of hepatocyte nuclear factor 1 alpha (TCF1); pterin-4-alpha carbinolamine dehydratase
PCBP1	poly(rC)-binding protein 1; HNRPE1; hnRNP-E1; heterogenous nuclear ribonucleoprotein X
PCNA	Hs.78996; proliferating cell nuclear antigen
PCNAL	proliferating cell nuclear antigen-like
POLA	"Hs.81942; polymerase (DNA directed), alpha"
POLB	"Hs.1894; polymerase (DNA directed), beta"
POLD1	"Hs.65383; POLD; polymerase (DNA directed), delta 1, catalytic subunit (125kD)"
POLD2	"polymerase (DNA directed), delta 2, regulatory subunit (50kD)"
POLE	"polymerase (DNA directed), epsilon"
POLE2	"polymerase (DNA directed), epsilon 2; DPE2"
POLG	"Hs.80961; polymerase (DNA directed), gamma"
POLG2	"polymerase (DNA directed), gamma 2, accessory subunit; HP55; POLB; MTPOLB; polymerase (DNA directed), gamma 2, accessory subunit"
POLH	"polymerase (DNA directed), eta; XP-V; RAD30A"
POLI	RAD30B; polymerase (DNA directed) iota; RAD30 (S. cerevisiae) homolog B
POLQ	"polymerase (DNA-directed), theta"
POLR2A	polymerase (RNA) II (DNA directed) polypeptide A (220kD); Hs.60366; POLR2; POLRA
POLR2B	polymerase (RNA) II (DNA directed) polypeptide B (140kD)
POLR2C	Hs.79402; polymerase (RNA) II (DNA directed) polypeptide C (33kD)
POLR2D	polymerase (RNA) II (DNA directed) polypeptide D
POLR2E	polymerase (RNA) II (DNA directed) polypeptide E (25kD)
POLR2F	polymerase (RNA) II (DNA directed) polypeptide F
POLR2G	polymerase (RNA) II (DNA directed) polypeptide G; RPB7
POLR2H	polymerase (RNA) II (DNA directed) polypeptide H
POLR2I	polymerase (RNA) II (DNA directed) polypeptide I (14.5kD)
POLR2J	polymerase (RNA) II (DNA directed) polypeptide J (13.3kD)
POLR2K	polymerase (RNA) II (DNA directed) polypeptide K (7.0kD)
POLR2L	polymerase (RNA) II (DNA directed) polypeptide L (7.6kD)
POLRMT	polymerase (RNA) mitochondrial (DNA directed); h-mtRPOL
PP32	"acidic nuclear phosphoprotein, pp32; Putative human HLA class II associated protein I; LANP; PHAP1; ANP32; I1PP2A"
PP32R1	"acidic nuclear phosphoprotein, pp32, related, 1"
PP32R2	"acidic nuclear phosphoprotein, pp32, related, 2"
PRKDC	"HYRC1; protein kinase, DNA-activated, catalytic polypeptide; XRCC7; hyper-radiosensitivity of murine scid mutation, complementing 1; DNAPK"
PTB	Hs.102127; HNRPI; HNRNPI; polypyrimidine tract binding protein (heterogeneous nuclear ribonucleoprotein I); Hs.75971
PUAB4	"protein spot in 2-D gels (nuclear polypeptide, 100kD, relative pI 6.25)"
RBBP2H1A	PLU-1; putative DNA/chromatin binding motif; retinoblastoma-binding protein 2 homolog 1A
RECQL	Hs.1536; RecQ protein-like (DNA helicase Q1-like)

Name	DNA Binding Protein Description
RELA	v-rel avian reticuloendotheliosis viral oncogene homolog A (nuclear factor of kappa light polypeptide gene enhancer in B-cells 3 (p65)); NFKB3
RELB	v-rel avian reticuloendotheliosis viral oncogene homolog B (nuclear factor of kappa light polypeptide gene enhancer in B-cells 3)
REV3L	"REV3 (yeast homolog)-like, catalytic subunit of DNA polymerase zeta; POLZ"
SAMSN1	"SAM domain, SH3 domain and nuclear localisation signals, 1"
SATB1	Hs.74592; special AT-rich sequence binding protein 1 (binds to nuclear matrix/scaffold-associating DNA's)
SATB1	Hs.74592; special AT-rich sequence binding protein 1 (binds to nuclear matrix/scaffold-associating DNA's)
SCNN1D	"sodium channel, nonvoltage-gated 1, delta; dNaCh; ENaCd"
SIP2-28	CIB; KIP; calcium and integring binding protein (DNA-dependent protein kinase interacting protein)
SON	SON DNA-binding protein; Hs.92909; DBP-5
SP100	Hs.77617; nuclear antigen Sp100
SP140	SP140-PEN; nuclear antigen Sp140
SPBPBP	DNA-binding protein amplifying expression of surfactant protein B
SPF31	splicing factor similar to dnaJ
SPN	NUDR; suppressin (nuclear deformed epidermal autoregulatory factor-1 (DEAF-1)-related)
SRM160	Ser/Arg-related nuclear matrix protein (plenty of prolines 101-like)
SSBP	single-stranded DNA-binding protein; Hs.923
SSNA1	Sjogren's syndrome nuclear autoantigen 1; nuclear autoantigen of 14 kDa; N14; NA14
TCF1	"Hs.73888; HNF1; LFB1; transcription factor 1, hepatic; LF-B1, hepatic nuclear factor (HNF1), albumin proximal factor"
TCF2	"transcription factor 2, hepatic; LF-B3; variant hepatic nuclear factor; LFB3; VHNF1; HNF1beta"
TCF7	"transcription factor 7 (T-cell specific, HMG-box); Hs.100010; Hs.3002; TCF-1"
TCF7L1	"transcription factor 7-like 1 (T-cell specific, HMG-box); TCF-3"
TCF7L2	"transcription factor 7-like 2 (T-cell specific, HMG-box); TCF-4"
TDP-43	TAR DNA-binding protein-43
TIF2	GRIP1; NCOA-2; NCOA2-PENDING; nuclear receptor coactivator 2
TITF1	NKX2A; thyroid transcription factor 1; TTF-1; NK-2 (Drosophila) homolog A (thyroid nuclear factor)

Assembly of the inducible cassette is generally performed using standard molecular biology techniques such as restriction endonuclease digestion and ligation as described in Sambrook *et al.*, Molecular Cloning: A Laboratory Manual, 2nd Ed., Cold Spring Harbor Laboratory, 1989. In general, the inducible promoter is ligated upstream of the target insertion domain such that the promoter may induce expression of the target sequence. In addition, the selecting sequence is generally ligated in a different reading frame from the inducible promoter such that expression of the selecting sequence does not result in induction of the target.

There may be some situations in which the addition of a reporter gene is desirable. If a reporter gene is used, the positioning of the reporter gene may be different depending on the reporter gene's function. Of course, when a reporter gene is used to detect insertion of the target into the subcloning vector, the reporter gene is generally positioned such that the target insertion domain is within the reporter gene allowing the detection of an inserted target sequence by disruption of the reporter gene's expression. In contrast, when the reporter gene is used to detect insertion of the inducible construct into a mammalian cell, the reporter gene is positioned outside of the target insertion domain such that an inserted target does not disrupt expression of the reporter.

Orientation of the components that comprise the inducible cassette may further depend on the number of promoters within the cassette and the number of target sequences within the inducible cassette.

When the inducible cassette consists of one promoter, it may be operably linked to the target sequence such that it initiates transcription of the target sequence. One skilled in the art will recognize the advantages of incorporating two or more promoters within the inducible cassette.

When two or more identical target sequences are inserted into the inducible cassette, it may be desirable to have one promoter or set of tandem promoters induce expression of the entire transcript. Alternatively, when different target sequences are inserted into the same inducible cassette, it may be desirable to have at least two promoters each able to induce expression of a target individually. For example two target sequences may be inserted in different reading frames allowing the selective induction by each promoter.

The subcloning vector is a double stranded circular nucleic acid sequence able to replicate and be transcribed within a host cell and able to accept an inducible cassette. A subcloning vector preferably comprises an origin of replication site ("ori") and an inducible cassette insertion domain. Similar to the inducible cassette, the subcloning vector may further comprise a reporter gene able to detect the insertion of the inducible cassette and a selecting gene able to select for cells expressing the subcloning vector. The type of subcloning vector used with the present invention may depend on the size of the inducible cassette to be inserted. When the subcloning vector is a plasmid the inducible cassette may be from about 0.1 kb to about 15 kb, preferably from about 0.5 kb to about 10 kb, and most preferably from 1 kb to 6 kb. Plasmids that may be used in the present invention include, for example, puc18, puc19, and pBluescript II KS. Preferably the plasmid is pcDNA4/TO.

Endonuclease cleavage sites may be added to allow the removal or insertion of components in the subcloning vector by PCR. For example, when the same selecting sequence is present in both the inducible cassette and the subcloning vector, a cleavage site may be engineered allowing the removal of one of the selecting sequences and insertion of an alternative selecting sequence. The addition of sequences may be performed using standard PCR techniques whereby primers are designed to insert a desired endonuclease cleavage site.

Similarly, endonuclease cleavage sites within the target insertion domain may be modified such that a target sequence may be removed from and inserted into the inducible construct without removal of the inducible cassette from the subcloning vector. This allows efficient transfer of target sequences into and out of the inducible construct. For example, a cleavage site may be removed by PCR or by ligation of a DNA sequence inactivating the cleaved site.

One skilled in the art will recognize that the same strategies comprising restriction and ligation of a target cDNA sequence into an inducible cassette are applicable in inserting the inducible cassette into the subcloning vector.

In addition, more than one inducible cassette may be inserted into a subcloning vector such that a single inducible construct may express one or more target sequences. When multiple inducible cassettes are added to the subcloning vector they may be inserted in different reading frames such that each inducible cassette may be induced individually. However, one skilled in the art would recognize that induction of multiple inducible cassettes in different reading frames within the same cell would require different inducer molecules or inducing conditions allowing for selective induction. For example in one configuration an assembly protein may be required for functional activity of the target sequence. In this case the assembly protein may be inserted within a second inducible cassette allowing the assembly protein to be induced prior to induction of the target sequence. In yet another configuration, an additional inducible cassette may be inserted into the subcloning vector that encodes a growth factor or differentiation activator to enhance cell growth and promotes differentiation upon induction. Alternatively, in another configuration a reporter gene operably linked to a nuclear hormone receptor gene may be inserted into the subcloning vector such that induction produces a change in reporter activity that can be measured.

As previously discussed, the inducer molecule or induction condition allows the user to selectively induce the transcription of the target sequence. Correspondingly, the inducer molecule or induction condition may be different depending on the inducible promoter. For example, Ponasterone A is a molecule that induces the expression of a vector comprising an ecdysone promoter (Invitrogen, Carlsbad, CA) and tetracycline is a molecule that induces the expression of a vector comprising a tetracycline-dependent promoter (Invitrogen, Carlsbad, CA; Clontech, Palo Alto, CA).

A change in an environmental condition may also be utilized for induction. For example, heat shock promoters are known to induce transcription upon an increase in temperature. Consequently, for example by controlling the temperature of the media the user is able to control induction of a target sequence.

A repressor may be used with an inducer or may be used in place of an inducer to regulate induction. A repressor is a compound that interacts with a nucleotide sequence interfering with transcription. Therefore, induction generally occurs in the absence of a repressor. For example zinc finger proteins ("ZFPs") are commonly used as repressors. Particularly potent ZFPs comprise

a Kruppel-associated box ("KRAB") domain (Vissing *et al.*, *FEBS Letts.* 369:153-157, 1995; Beerli *et al.*, *Proc. Natl. Acad. Sci.* 95:14628-14633, 1998).

A second inducible construct may encode an inducer or a repressor able to control transcription of an endogenous target. For example, an inducible expression vector encoding a regulator, such as for example VP16, FKBP or ZFP, may be used to modulate induction of the target wherein the inducer initiates transcription of the regulator and the regulator initiates transcription of the target sequence. In this configuration there may be an additional reporter within the inducible cassette or within the regulatory construct allowing the induction to be monitored between constructs.

Unlike traditional expression systems, the present invention provides an internal control because of the ability to initiate or terminate the expression of the target sequence. Therefore, modulation may be determined by comparing values collected prior to and after induction of the target sequence. In contrast, traditional methods for utilizing expression vectors generally involve transfection of an expression vector in one population of cells and transfection of a control in another population. However because there is variance in expression between populations and in stability of expression over time, modulation is difficult to measure.

The use of homologous recombination to produce the inducible target may be useful for the present invention. In this method, the endogenous promoter of an endogenous target gene is replaced with the inducible promoter of the present invention. The DNA constructs derived by homologous recombination are useful for operatively linking exogenous regulatory and structural elements to endogenous coding sequences in a way that precisely creates a novel transcriptional unit, provides flexibility in the relative positioning of exogenous regulatory elements and endogenous genes and, ultimately, enables a highly controlled system for identification of modulatory compounds.

Upon homologous recombination, the inducible regulatory sequence of the construct is integrated into a pre-selected region of the target gene in a chromosome of a cell. This region should be within 5kb of a coding exon and more preferably within 1 kb of a coding exon for the gene of interest. The resulting new transcription unit containing the construct-derived inducible regulatory sequence alters the expression of the target gene.

According to this method, the inducible cassette may comprise 5' and 3' insertion adapters enabling it to be inserted into the genome of the host organism by homologous recombination using standard recombination techniques (Mansour *et al.*, *Nature* 336:348, 1988; U.S. Pat. No. 6,270,989 to Treco, U.S. Pat. No. 6,242,218 to Treco, all of which are incorporated in their entireties herein by reference). In this configuration, the insertion adapters are complementary to the non-coding region of the genome where the inducible cassette is to be inserted. 5'and 3' adapter sequences permit homologous recombination of a desired sequence into a selected site in the host genome. These adapter sequences are homologous to (i.e., able to homologously recombine with) their respective

target regions in the host genome. The adapter sequence is homologous to a pre-selected target site in the genome with which homologous recombination is to occur. It contains at least 20 (e.g., at least 50 or 100) contiguous nucleotides from the region of the target gene. By "homologous" is meant that the targeting sequence is identical or sufficiently similar to its genomic target site so that the targeting sequence and target site can undergo site-specific recombination. A small percentage of base pair mismatches is acceptable, as long as homologous recombination can occur at a useful frequency. To facilitate homologous recombination, the adapter sequence is preferably at least about 20 (e.g., 50, 100, 250, 400, or 1,000) base pairs ("bp") long.

A circular DNA construct can employ a single adapter sequence, or two or more separate adapter sequences. A linear DNA construct may contain two or more separate targeting sequences. The target site to which a given targeting sequence is homologous can reside within an exon and/or intron of the target gene, upstream of and immediately adjacent to the target gene coding region, or upstream of and at a distance from the target gene coding region.

The use of homologous recombination to insert an inducible promoter to the regulatory region of an endogenous gene may encompass the expression of a gene which is normally silent in the cell. The use of homologous recombination may also cause the increased expression level of the endogenous gene, or may change the regulation pattern of a gene.

II. Cell Transfection

As described above, the traditional methods utilizing expression vectors require multiple transfections. In particular, the expression vector is inserted into one aliquot of cells of a sample while one or more control vectors are inserted into additional aliquots of the sample. This method is undesirable because transfection and expression efficiencies may vary significantly from sample to sample.

The methods of the present invention do not require the transfection of additional controls. Once cells have been transfected with the inducible vector construct a steady state measurement maybe obtained by assaying the cells in the absence of inducer. An activated state measurement may be made by assaying the cells in the presence of inducer and the modulation capability of a compound may be measured by assaying the cells in an activated state in the presence of the compound. Correspondingly, a steady state measurement in the presence of compound may be made following that activated state by assaying the cells once the inducer has been removed. However, one skilled in the art would recognize that careful selection may be necessary to achieve determination the desired concentration of inducer for induction during development of the assay. For example, a bulk transfection may be performed and individual cells selected to determine inducibility by measuring the target expression, either by RT-PCR/Northern blotting, western blotting, observation of a phenotypic change, or preferably all of the above. Clones with the desired expression levels are then selected, isolated and cultured to be assayed against possible modulatory compounds.

The recipient cell may be any in which the target is not endogenously active or has low or negligible activity, is able to grow from low densities, and is amenable to mass culture. Additionally, when secondary modification of the translated target is desirable such as glycosylation, the cell must be able to perform any such secondary modification. In addition, the desired recipient cell should have the appropriate signaling mechanisms for the target to initiate a phenotypic change that may be measured. For example, if the target is a GPCR, the desired cell would preferably have intact adenylyl cyclase and calcium signaling pathways. A number of recipient cells may be utilized with the present invention such as for example CHO, CHO-K1, HEK293, COS, Vero, RBL, SH-SY5Y, and U20S cells.

One factor to consider when determining whether a cell is appropriate for transfection is its endogenous expression of the target sequence. Activity may be measured using a variety of techniques such as RT-PCR, Northern analysis, and array hybridization. Suitable hosts would be those that do not have the target sequence or express it in a low level. More specifically, if a target cannot be detected by RT-PCR, it is highly unlikely that it will mediate a signaling event and therefore the cells would be desirable recipients.

Selection of clonal cell lines may be performed by growing cells from low densities and isolating colonies that desirably express the target sequence. More preferably the recipient cells are grown from single cell colonies. Recipient cells may be chosen by their ability to grow in culture to high density. In large preparations a high concentration of cells may be required. In this configuration non-adherent cells may be grown in spinner flasks and adherent cells may be grown in roller bottles.

Transfection may be performed by a variety of methods that allow vector insertion into a cell such as for example calcium phosphate and electroporation (Sambrook *et al.*, Molecular Cloning A Laboratory Manual, 1987).

Transfected cells may be selected from those that do not express a selecting sequence by a variety of methods. Typically, when the construct comprises a selection sequence encoding resistance to a selective agent, positive cells are selected by the addition of the corresponding selective agent. Alternatively, optical assays may be used to select positive colonies when the inducible cassette comprises a reporter gene such as luciferase. In addition transfected cells may be selected using fluorescent activated cell sorting (FACS). Following selection cells are plated and grown to multicellular colonies.

Plates containing multicellular colonies are further passed into daughter plates such that there are about ten daughters per mother plate. Cells are then selected by RT-PCR and/or immunoblot analysis and target dependent responses.

III. Selection of Cells by Target-Dependent Responses

After transfection and selection of stable cell lines containing the inducible vector, the cells are tested for inducible expression of the desired mRNA. For example, upon transfection of the vector illustrated in Figure 1 to CHO cells as described in Example 2, and subsequent selection for the presence of the plasmid, putative positive cells were tested for induction of KCNC1 mRNA expression after addition of the inducer molecule, tetracycline, following the method described in Example 3. KCNC1 mRNA was amplified by RT-PCR using primers specific for the KCNC1 gene as described in Example 3, then separated by agarose gel electrophoresis (Figure 2). The PCR products of several clones (# 7, 13, 22) were found to express the KCNC1 mRNA when induced.

Furthermore, the inducible production of the target protein should be ensured. Using the above-described system as an example, the tetracycline-inducibility of the KCNC1 protein was determined using an immunoassay according to the method described in Example 2. Briefly, a primary antibody that recognizes the KCNC1 protein was added to the assay well. After a brief wash, the secondary antibody, conjugated to horseradish peroxidase to allow for color development, was added to the well. Upon development of the immunoassay, the tetracycline-induced well was darker than the control well (Figure 3), indicating the presence of the KCNC1 protein. One of skill in the art will appreciate that the inducibility of any target sequence useful for the present invention can be determined in a similar manner.

Positive cells are then tested for target-dependent responses by measuring the appropriate response in both the absence and presence of the inducer in order to identify those cells expressing a functional target sequence.

Figure 4 demonstrates the use of a cell containing an inducible target as described herein for screening for molecules that modulate its activity. In this example, fluorescent dyes are used to assay for changes in membrane potential, essentially as described in Example 4. CHO cells induced to produce the KCNC1 target polypeptide are subsequently able to show a response (i.e. a change in fluorescence intensity of the indicator dye) when the modulator KCl is added.

The addition of the KCNC1 inhibitor aminopyridine to the induced cells lessened the response to KCl addition (Figure 5). $BaCl_2$, a K+ channel inhibitor, also ameliorated the response to KCl addition (Figure 6).

Target-dependent responses may also be measured or observed by secondary effects that demonstrate the expression of the target sequence such as by measuring changes in cellular adhesion and may vary depending on the target sequence.

Expression of a G-protein coupled receptor at high levels generally causes activation of a functional response (Wess *et al.*, *J. Pharmacol. Ther.* 80:231-264, 1998; Choi *et al.*, *J Neurosci Methods.* 94:217-25, 2000). Consequently, when the target sequence comprises a G-protein coupled receptor coupled to Gi, an assay that measures a decrease in cellular cyclic AMP ("cAMP") levels is desired. When the GPCR is coupled to Gs and is constitutively active and inducibly

expressed, an assay that measures increases in cAMP levels is desired. Furthermore, when the GPCR is coupled to a Gq family G-protein, is constitutively active and inducibly expressed, an assay that measures intracellular calcium levels may be desired. Examples of techniques to measure cAMP levels are competitive binding assays (the Biotrak enzyme immunoassay (Wallac, Piscataway, NJ)) or a Fluorescence polarization assay (NEN Life Science Products, Boston, MA)(Post *et al.*, *Methods Mol. Biol.* 126:363-74, 2000).

Intercellular calcium levels may be detected by commercially available dyes such as Fura, Fluo or Indo (Molecular Probes, Eugene, OR). These dyes bind to calcium and cause a shift in the absorbance of the dye (Palmer *et al.*, *Am. J. Physiol.* 279, C1278, 2000; Collet *et al.*, *J. Physiol.* 520: 417-429, 1999; *Meth. Molec. Biol.* 114, (David Lambert, ed. Humana Press), 1999; 376). Detecting a dye may be performed by flow cytometric analysis such as for example at 356/478 nm for indo-1.

When cAMP levels are assayed at least four daughter plates containing the construct may be used to test at least four conditions. The first plate is utilized as a control comprising transfected cells in which endogenous cAMP levels are measured. The second plate is utilized as a positive control and contains an agent, such as Forskolin, able to elevate endogenous cAMP levels. Preferably, the cAMP level is elevated to about 80% of maximum. This is determined by running a concentration range and monitoring the resulting cAMP levels. Maximum is the concentration at which the curve reaches a plateau. The third plate comprises an inducer able to induce transcription of the target sequence, and the cAMP level is monitored over time. The fourth includes the inducer and the test compounds. When the maximum induction of the target construct occurs, cAMP levels may be measured over time and may continue until returning to steady state. Recordings are made documenting the elevation or depression of cAMP in response to target induction in order to determine the optimum amount of inducer for each induction procedure. Cells that show changes in the level of cAMP greater than about three standard deviations of the population average following induction are sorted into multiwell plates and grown to multicellular colonies.

When calcium levels are assayed, two conditions are preferable. The first comprises transfected cells absent inducer, and the second comprises adding an inducer and measuring calcium levels by detecting the fluorescent properties of the calcium sensitive-dye over time using a fluorometer. Cells that show changes in the level of calcium dependent fluorescence greater than about three standard deviations of the population average following induction are sorted into multiwell plates and grown to multicellular colonies.

Induction of an ion channel target will generally increase the number of channels in the cell membrane and result in a change in membrane potential. Therefore, when the target is an ion channel, the assay preferably measures a change in membrane potential. Fluorescent dyes such as DIBAC (Molecular Probes, Eugene, OR) may detect changes in membrane potential (Epps *et al.*, *Chem. Phys. Lipids* 69:137-150 1994; Waggoner, *J. Membr. Biol.* 27:317-34, 1976).

When the target sequence is a nuclear hormone receptor or transcription factor, the direct phenotypic readout may be assayed by expression of an endogenous marker gene (Davis D.L. and Burch J.B., *Mol. Endocrinol.* 10:937-44, 1996) or by using a promoter-reporter construct (Martinez E. *et al., EMBO J.* 6:3719-27, 1987). The promoter-reporter construct may be any reporter sequence that is operably linked to a promoter and an enhancer sequence that is responsive to the receptor or transcription factor, such that when the promoter is active, the reporter verifies translation of the construct. For example luciferase may be linked to the HSV thymidine kinase minimal promoter and an estrogen response element. Briefly, when the promoter is activated by binding of the estrogen receptor to the response element, the enzymatic activity of luciferase in cell extracts may be detected upon addition of a suitable luciferase substrate (such as Luc-Lite, Packard Bioscience, Meriden, CT.) by measurement of the light emitted.

Because receptors for growth factors, angiogenesis factors, or cytokines are known to couple through specific intracellular pathways to activate gene expression, the promoter-reporter strategy may also be useful in measuring activity. Growth factor or angiogenesis factor receptor activation may be measured either by autophosphorylation (Smaill J.B. *et al., J. Med. Chem.* 44:429-40, 2001), or by promoter-reporter constructs (Ghezzo F. *et al., J. Biol. Chem.* 263:4758-63, 1988). Cytokine receptor activation may be measured by phosphorylation of STAT proteins (Spiotto M.T. and Chung T.D., *Prostate* 42:88-98, 2000) or by STAT reporter constructs (Gaemers I.C. *et al., J. Biol. Chem.* 276:6191-9, 2001).

When the target sequence encodes a transporter, changes in intracellular pH may be measured to determine activity. Ion transporters such as proton pumps or anion transporters where hydrogen ions are accumulated within the cell, lead to a change in pH. For example, changes in activity of the sodium/hydrogen exchanger would alter the intracellular proton concentration. The activity of the sodium/hydrogen exchanger is coupled with the activity of other cation exchangers and thus intracellular pH is an indication of the activity of all cation exchangers. Intracellular pH may be measured by the detection of added dyes such as SNARF (Molecular Probes, Eugene, OR) that change their optical properties in response to changes in pH. Dyes such as SNARF may be measured using flow cyomtetric anaylsis (Burchiel S.W. *et al., Methods* 21:221-30, 2000, van Erp P.E. *et al.*, Cytometry 12:127-32, 1991).

When the target sequence encodes a protein that induces apoptosis such as by stimulation of the Fas receptor, different markers representing different points within the chain of cellular events may be measured such as activation of caspases (Smolewski P. *et al., Cytometry* 44: 73-82, 2001), display of cell surface markers, intracellular acidification, calcium mobilization, and changes in permeability. Dyes that change their optical properties in response to cellular pH, calcium, and membrane permeability such as SNARF (van Hooijdonk C.A. *et al., Cell Prolif.* 30:351-363, 1997), FURA (Palmer B.M. and Moore R.L., *Am. J. Physiol.* 279:C1278 2000), and propidium iodide (Eray M. *et al., J. Cytometry* 43:134-142, 2001) may be used to detect activation. Preferably, the

dyes fluoresce at different detectable wavelengths so that multiple independent measurements may be made simultaneously and detected using a flow cytometer or plate reader.

IV. Testing Compounds for the Ability to Modulate the Activity of an Induced Target Sequence Gene Product.

Once cells that selectively express the target sequence have been identified and the desired inducing conditions have been determined, cells are grown and assayed to determine the effects of potential modulatory compounds. Testing for modulation of the expressed target sequence occurs prior to induction and after induction. Testing may also occur once induction has ceased and the cell is allowed to return to its "steady state." Differences in the measurements between the "steady state" and "activated state" in the presence and absence of these compounds allows one to determine whether modulation has occurred.

A "steady state" measurement is taken prior to induction. The "steady state" measurement comprises cells transfected with inducible construct in the presence or absence of a potential modulator molecule compound. The concentration of the test cells in the assay are generally from about 1 x 10^5 cells/mL to about 2 x 10^6 cells/mL. However, depending on the cell lines selected, one skilled in the art would recognize that the choice of inducible constructs and assays may require routine optimization.

Cells may be plated into multiwell plates and inducer added. Potential modulatory compounds may be added at the time expression commences. Control wells within the plate may receive either no inducer or compound, or inducer with no compound. The data may be analyzed to determine whether any of the compounds tested cause a signal deviation greater than about 3 standard deviations from the control wells that receive only inducer. During testing the control wells are monitored to ensure that the target is expressed and functionally active. Compounds identified as having activity may be tested against non-induced cells in a second identical assay excluding inducer to ensure that their effects are target related, rather than having an affect on basal activity.

The inducer is added at a concentration that produces a measurable change in the expression of the target by testing for target-dependent responses. The target sequence is verified by methods previously described. In addition the concentration of inducer will depend on the cell line, the assay, and the construct as previously described.

"Activated state" measurements are compared to "steady state" measurements to determine whether the potential modulator molecule has modulated the expressed target sequence. For example, modulation of a G-protein coupled receptor may be demonstrated by a change in cAMP or cellular calcium levels during activation.

Compounds that test positive are then assayed to determine their effects on the induction mechanism to identify false positives. One method to identify false positives is to test the compounds on a control cell line. The control cell line is preferably of the same cell type as the test

cell line and may comprise a reporter gene such as luciferase in place of the target sequence. If the reporter gene is inhibited luciferase will not be detected and it is likely that the compound is affecting the induction process and not the expressed target. When this occurs, the compound is no longer considered as a potential modulator molecule under the current test conditions.

In addition positive compounds may be tested against a family of proteins to determine their specificity for a particular member protein in that family. For example, Clozapine is known to inhibit D4 and 5HT2A/C receptors. In this configuration multiple constructs may be created where each expresses a G-protein coupled receptor and each transfected into a different cell.

The present invention may also be used to further define or study a biological pathway such as for example an enzymatic cascade pathway. More specifically one could place a regulatory kinase such as MAP kinase under inducible control. Induction of the kinase to high levels may activate the MAP kinase cascade. Alternatively, one may engineer many signaling molecules to be 'dominant negative' e.g. 'kinase dead' mutants where key catalytic residues of the enzyme are mutated, or isolated DNA binding domains of transcription factors. Inducible expression of these mutants may cause loss of function of the signaling pathway and may be useful in target validation studies.

V. A Kit for Identifying Modulatory Molecules

A kit for identifying modulatory molecules may be any kit comprising a cell line that conditionally expresses a target sequence and an inducer able to induce expression of a target. The kit may further comprise a fluorescent dye able to detect a change in a secondary effect that suggests binding of the target to a modulatory molecule, a buffered saline solution, and culture media.

The cell lines may be provided growing in microtitre plates or flasks at 37 C or frozen in vials or microtitre plates in liquid nitrogen. If frozen, the cells are thawed and resuspended in growth media. Standard growth media is provided with the cells and is typically DMEM+10% FCS. The membrane-potential sensitive dye is prepared as a stock solution in DMSO and is diluted in assay media. Preferred assay media is PSS + glucose or hybridoma media (Sigma, Saint Louis, MO).

When the target is an ion channel, the cell line may be CHO or HEK293, the fluorescent dye may be DIBAC, the buffered saline solution may be PBS, and the culture media may be DMEM. When the target is a receptor (GPCR, cytokine or nuclear hormone) the cell line may be CHO or HEK293, the fluorescent dye may be DIBAC or FURA, the buffered saline solution may be PBS, and the culture media may be DMEM.

The above disclosure generally describes the present invention. A more complete understanding can be obtained by reference to the following specific examples which are provided herein for purposes of illustration only and are not intended to limit the scope of the invention.

EXAMPLES

Example 1

Insertion of the Mouse Potassium Voltage-Gated Channel KCNC1 Gene Into the pcDNA4/TOb Inducible Expression Vector

Plasmid number 63333 (ATCC, Rockville, MD) containing the mouse potassium voltage-gated channel KCNC1 cDNA, the mammalian expression vector pcDNA4/TOb (Invitrogen, Carlsbad, CA) were commercially obtained. Both were digested with the restriction enzymes *Kpn*I and *Pst*I (New England Biolabs, Beverly, MA). The 2 kb KCNC1 gene fragment and the pcDNA4/Tob vector were gel purified, ligated and transformed into competent Top10F' *E.coli* (Invitrogen, Carlsbad, CA). Positive clones were identified by restriction analysis of plasmid DNA and confirmed by DNA sequencing. Plasmid DNA for transfection was prepared with an Endotoxin free kit (Qiagen, Valencia, CA).

Example 2

Transfection of the Inducible Expression Vector Target Construct

The pcDNA4/Tob/KCNC1 plasmid (Figure 1) was transfected into T-Rex CHO cells (Invitrogen, Carlsbad, CA) by the following procedure. Cells were seeded into a 6-well plate at $2x10^5$ cells per well. The next day cells were transfected using FuGene Reagent (Roche, Indianapolis, IN). The following morning transfected cells were split 1:10 into a 10 cm plate. Twenty-four hours later selection in 400 μg/mL zeocin (Invitrogen, Carlsbad, CA) was initiated, and continued for two weeks. Individual colonies of zeocin resistant cells were isolated using cloning paper (Scienceware, Pequannock, NJ) and passaged into a 24 well plate.

When cells became confluent, the clones were split in triplicate among 24-well plates. To identify clones that were able to express KCNC1, One set of clones was induced to express KCNC1 with 10 ug/mL tetracycline for 24 hours before cells were processed for immunohistochemistry. An identical set of non-induced clones was also processed for immunohistochemistry. Clones producing the KCNC1 protein were identified using an affinity-purified rabbit antibody to Kv3.1b (Sigma, St. Louis, MO), the rat homologue of the mouse KCNC1 (NEB, Ontario, Canada), and a secondary goat-anti rabbit antibody conjugated to horseradish peroxidase (NEB, Ontario, Canada). The assay was developed using TrueBlue Peroxidase Substrate (KPL Inc., Gaithersburg, MD). Clones that expressed KCNC1 in 100% of the cell population when induced and in 0% of the cell population when not induced were saved and expanded in a third 24-well plate. All clones were maintained in zeocin.

Example 3

Confirming the Induction of the Mouse Potassium Voltage-Gated Channel KCNC1 Gene

Induction of the KCNC1 gene was confirmed by RT-PCR analysis of mRNA and by immunohistochemistry.

PCR was used to verify production of KCNC1 mRNA (Figure 2). Two samples each containing $2x10^4$ cells were collected from clones 7, 13, and 22. The first sample was a control whereby there was no induction and the second sample was induced with 10 μg/mL of tetracycline. The mRNA was reverse-transcribed into cDNA using SuperScriptII (Invitrogen, Carlsbad, CA). PCR was performed in a GeneAmp 9600 thermocycler (Applied Biosystems, Foster City, CA) using a forward primer (5'-CCACCAGACGTACCGCTCATC-3', SEQ ID NO. 2) and reverse primer (5'CGGTGCTGGCGATAGGTCATC-3', SEQ ID NO. 3) specific for the expressed KCNC1 sequence. PCR products were separated on a 1.5% agarose gel and stained with SYBR Gold (Molecular Probes, Eugene, OR). KCNC1 induction was detected in induced cells but was absent in non-induced cells.

The stable, zeocin-resistant cell lines containing the KCNC1 gene were once again tested for their ability to produce the KCNC1 protein upon induction (Figure 3), following essentially the same method as described in Example 2, above.

Example 4

Method of Screening and Identifying a Modulator Molecule for an Ion Channel

A membrane potential assay demonstrated depolarization of the an induced population of cells in comparison to a non-induced cell population upon the addition of potassium chloride in 50 mM steps (Figure 4). A KCNC1 positive TREX/CHO clone was plated at $3x10^6$ cells in replicate 10 cm tissue culture dishes. After 24 hours one dish was treated with 10 μg/mL deoxycycline to induce KCNC1 expression. After a 24 hour induction period, both induced and uninduced cells were harvested with trypsin, counted, and adjusted to equal cell densities in hybridoma media (Sigma, St. Louis, MO). A solution of 3.3×10^5 cells and 0.4 μM of each Disbac5Me4 and Disbac3Me4 in hybridoma media was stirred in a cuvette in a JY- Fluormax-2 fluorometer (JY, Edison NJ). Fluorescence intensity from 540 nm excitation and 690 nm emission was measured over time. The extracellular potassium chloride level was adjusted to 50 mM, 100mM, and 150 mM with 3 N KCl at the indicated times. Each cell population was tested in triplicate and the mean and standard error (SE) were determined.

To demonstrate inhibition of KCNC1, the inhibitors 4-aminopyridine (900 μM) and $BaCl_2$ (30 mM) were pre-incubated with cells at least 30 minutes prior to addition of membrane potential dyes and fluorescence measurement. 4-aminopyridine is a known specific inhibitor of Kv3.1b (Grissmer *et al.*, *Molec. Pharmacol.* 45:1227-1234, 1994; Kirsch and Drewe, *Jour. Gen. Physiol.* 102:797-816, 1993; Grissmer *et al. Jour. Biol. Chem.* 267:20971-20979, 1992), the human homologue of KCNC1. $BaCl_2$, another known inhibitor of K^+ channels (Lopes *et al, J Biol. Chem.* 276:24449-52, 2001; Clarson *et al.*, *Placenta* 22:328-36, 2001), also results in a less polarized resting potential and a decreased response to depolarization with KCl, as shown in Figure 6. Pre-incubation with 30 mM KCl had no effect, ruling out the possibility that effects of $BaCl_2$ resulted from simply changing the ionic strength of the extracellular medium (data not shown). Each cell

population was tested in triplicate. The mean and SE are shown in the Figure 5 (aminopyridine) and Figure 6 ($BaCl_2$).

Example 5

Transfection and testing of an inducible expression vector construct containing a HERG-encoding gene

The pcDNA4/TOb/HERG plasmid (Figure 7) was transfected into T-REx CHO cells (Invitrogen, Carlsbad, CA). Cells were seeded into a 6-well plate at 2x105 cells per well. The next day cells were transfected using FuGene Reagent (Roche, Indianapolis, IN). The following morning transfected cells were split 1:10 into a 10cm plate. Twenty four hours later selection in 400mg/ml zeocin (Invitrogen, Carlsbad, CA) was begun, and continued for two weeks.

Individual colonies of zeocin resistant cells were isolated using cloning paper (Scienceware, Pequannock, NJ) and passaged into a 24-well plate. When cells became confluent the clones were split in triplicate among 24-well plates. One set of clones was induced to express HERG with 10mg/ml tetracycline for 24 hours before cells were processed for immunohistochemistry. An identical set of non-induced clones was also processed for immunohistochemistry. HERG expressing clones were identified using an affinity-purified rabbit antibody to HERG (Alomone Labs, Jerusalem, Israel). A secondary goat-anti-rabbit antibody conjugated to horseradish peroxidase (NEB, Ontario, Canada) was then detected using TrueBlue Peroxidase Substrate (KPL Inc., Gaithersburg, MD). Clones that expressed HERG in 100% of the cell population when induced and in 0% of the cell population when not induced were saved and expanded from the third 24-well plate. All clones were maintained in zeocin selection.

The HERG positive TREX/CHO clone 5J was plated at $3X10^6$ cells in replicate 10 cm tissue culture dishes. After 24 hours one dish was treated with 10mg/ml doxycycline to induce HERG expression. After 24 hours induction, both induced and uninduced cells were harvested with trypsin, counted and adjusted to the same cell density in hybridoma media (Sigma, St. Louis, MO). A solution of $1X10^5$ cells/ml and 0.4 μM each Disbac5Me4 and Disbac3Me4 in hybridoma media was stirred in a cuvette in a JY-Spex fluorometer. Fluorescence intensity from 540 excitation and 690 emission was followed over time. The extracellular potassium chloride was adjusted to 100mM with 3N KCl at the indicated time. 25nM pimozide was then added at the indicated time. Each cell population was tested in triplicate and the mean and SE are shown in Figure 8.

Example 6

Construction of an Homologous Recombination Vector Construct

The creation of the inducible target gene can be accomplished by a number of strategies, including the use of homologous recombination to replace a specific endogenous regulatory region of a gene with an inducible regulatory region. In a typical homologous recombination strategy, an adaptor fragment is introduced into the genome of recipient cells for insertion of a regulatory region upstream of the coding region of the target gene. Specifically, the targeting construct from which

this fragment is derived is designed to include a first targeting sequence homologous to sequences upstream of the target gene, a selectable marker gene, an inducible regulatory region, and a second targeting sequence corresponding to sequences downstream of the first targeting sequence but upstream of exon 1 of the target gene. This strategy allows the endogenous promoter of a target gene to be replaced with an inducible promoter. The resulting homologously recombinant cells can be induced to produce an mRNA transcript of the target gene.

For example, a homologous recombination vector containing the inducible promoter and the targeting sequences of a given target gene may be constructed by the following method. A restriction enzyme digestion of a subcloning vector such as pBS (Stratagene, Inc., La Jolla, Calif.) containing the genomic DNA sequences within 1-5 kb of coding regions of the gene of interest is designed (based on the restriction map of the target gene upstream region and data published from human genome sequencing) in order to isolate the desired DNA fragments corresponding to 1) an upstream homologous recombination target sequence 1 of the given gene, and 2) an upstream homologous recombination target sequence 2 of the given gene. The upstream fragments are then sequentially ligated to the plasmid containing the inducible promoter construct, so that the inducible promoter construct is between recombination target sequence 1 and 2. Optionally, one or more selectable marker genes may be added to the construct. The plasmid is then transformed into competent *E. coli* cells or other cells, including human cell lines, and colonies containing the above inserts are analyzed by restriction enzyme analysis to confirm the orientation of the insert.

Example 7

Method of Screening and Identifying a Modulator Molecule for an Endogenous Ion Channel Protein Using a Homologous Recombination Vector Construct

An inducible promoter and selectable marker are inserted by homologous recombination into a human tumor cell line that contains an endogenous copy of KCNC1, and transformed cells are selected using conventional techniques.

A membrane potential assay is then conducted using various candidate modulator molecules, by repeating the steps of Example 4 for each candidate molecule.

Example 8

Replacement of an endogenous promoter so as to obtain controllable expression of an endogenous gene (CNTF receptor).

The activation of the target gene can be accomplished by a number of strategies. In a typical strategy, a targeting fragment is introduced into the genome of recipient cells for insertion of a regulatory region, optionally including a non-coding exon and a functional, unpaired splice-donor site upstream of the coding region of the target gene. Specifically, the targeting construct from which this fragment is derived is designed to include a first targeting sequence homologous to sequences upstream of the target gene, a selectable marker gene, a regulatory region and a second targeting sequence corresponding to sequences downstream of the first targeting sequence By this

strategy, homologously recombinant cells produce an mRNA precursor in response to modulation of the regulatory region which, when translated, will produce the target gene product. Advantageously, the post-transcriptional processing of the mRNA precursor and of its protein product retains the characteristics of the native cell, unlike heterologously expressed cDNAs.

For example, the homologous recombination vector containing the inducible promoter and the target sequences of the noncoding region of the gene for the ciliary neurotrophic factor receptor (CNTFR), is constructed as follows:

Construction of CNTFR-DHR_SK_Pac_CMVTO vector. pPUR (Clontech, Palo Alto CA.) was digested with *Pvu*II and ligated with a *Not*I linker. The resulting plasmid was then digested with *Not*I and *Bam*HI to drop the *pac* gene expression cassette. The *Not*I-*Bam*HI *pac* cassette was ligated into pBluescript SK (Stratagene, San Diego, CA) to generate the plasmid SK_Pac. To construct the CNTFR-DHR_SK_Pac_CMVTO vector, CMVTO promoter was amplified from pcDNA4/TO_myc_hisB (Invitrogen, Carlsbad CA) with primers CMVTOUB 5'-GATCGGATTCGATATACGCGTTGACATTGATTAT (SEQ ID NO. 4) and CMVTOLE 5'-GATCGAATTCGCTTAAGTTTAAACGCTAGAGTCC (SEQ ID NO. 5) and cycling conditions: 30 cycles of 95 °C 30 sec, 55 °C 30 sec, 72 °C 1 min. PCR product was digested with *Bam*HI and *Eco*RI and cloned into SK_Pac to yield SK_Pac_CMVTO. The 3' homologous flanking arm was generated by digesting SK-6C with *Sap*I, filling in this site and digesting with *Xho*I to generate a 4.3 kB fragment containing some promoter sequences, the transcriptional start site and part of the first exon, excluding coding sequences. This 4.3 kB fragment was cloned into SK_Pac_CMVTO digested with *Eco*RV and *Xho*I to yield SK_Pac_CMVTO-CNTFR_3'. The 5' homologous flanking arm was generated by digesting a 2.5 kB *Not*I fragment from SK-6C and ligating into a CIP treated *Not*I digest of SK_Pac_CMVTO-CNTFR_3'. Clones were screened for the correct orientation by restriction digest analysis. Cloned PCR product and ligation junctions were confirmed by sequencing. The correct clone was called CNTFR-DHR_SK_Pac_CMVTO (Fig. 9). This plasmid contains the *pac* gene, under the control of SV40 early promoter and polyadenylation signal, for puromycin resistance, and two tetracycline operator 2 ($TetO_2$) sites within the human cytomegalovirus immediate-early (CMV) promoter, for controlling gene expression using doxycyline.

Transfection and Selection of Homologous Recombinant Clones. CNTFR-DHR_SK_Pac CMVTO vector was linearized with *Pvu*I. Linearized DNA was purified and sterilized by phenol/chloroform extraction and precipitated using ethanol. Recipient cells were isolated by transfecting HBL100 cells (ATCC, Manassas, VA) with pcDNA6/TR (Invitrogen, Carlsbad, CA) using FuGENE 6 (Roche Diagnostics, Indianapolis, IN) and maintaining in 10μg/ml Blasticidin (Invitrogen, Carlsbad, CA) to select for stable clones. A 70-80% confluent culture of recipient cells was trypsinized, washed with PBS and resuspended at $1X10^7$ cells/ml in hypoosmolar electroporation buffer (Brinkmann, Westbury, NY.). 400 μl aliquots were taken and mixed with 10

μg of linearized CNTFR-DHR_SK_Pac_CMVTO. Samples were incubated on ice for 10-15 minutes, transferred to chilled 4 mm gap electroporation cuvette and electroporated at 150V/7ms/LV using an ECM 830 electroporator (BTX, San Diego, CA). After electroporation, cells were immediately incubated on ice for 10-15 minutes and plated in 100 mm dish containing McCoys medium supplemented with 10% Fetal Bovine Serum. Cells were grown at 37°C for 2 days. On the second day, media was changed to media containing 10 μg/ml Blasticidin (Invitrogen, Carlsbad, CA) and 1 μg/ml Puromycin (Invitrogen, Carlsbad, CA). Puromycin selection was maintained for 12-15 days. When cells reached subconfluency, cells were induced with 5 μg/ml doxycycline (Sigma, St. Louis, MO) for 2 days.

Screening and Analysis of Recombinant Clones using Fluorescent Activated Cell Sorting (FACS). Cells were washed with PBS and harvested with cell stripper (Cellgro, Herndon VA). Cells were pelletted, washed with PBS, resuspended at 2-6X10^6 cells/ml with 200 μg/ml Rabbit IgG (R&D Systems, Minneapolis, MN) in PBS blocking solution and incubated for 30 minutes at 4°. The primary antibody, a polyclonal goat anti-human CNTFRα (R&D Systems, Minneapolis, MN), was added at 2 μg/ml and incubated for 30 minutes at 4°. Cells were washed three times with FACS buffer (PBS without Ca^{2+} and Mg^{2+} supplemented with 1 mM EDTA, 25 mM HEPES pH 7.0, 3% dialyzed serum). 2 μg/ml of secondary antibody, rabbit anti-goat conjugated to Alexa Fluor 488 (Molecular Probes, Eugene, OR), was added to the samples and incubated for 30 minutes at 4°. Cells were washed three times with FACS buffer. Flow cytometry analysis was performed on a FACScan (Becton Dickinson, Franklin Lakes, NJ) and FACS was performed on a FACS Vantage (Becton Dickinson, Franklin Lakes, NJ). For analysis and sorting, a region was drawn around the live cells of forward scatter vs. side scatterplot and all other plots were gated on this region. The negative population, density plots of uninduced samples and induced samples without primary antibody, were set on the first log of FL1 (Fig. 10). For sorting, a sort gate was placed on the top 5% of the positive population on the induced samples incubated with primary antibody. The sorted positive population was expanded and re-sorted using the same protocol for individual clones.

Example 9

Method of Screening and Identifying a Modulator Molecule for an Endogenous CNTF Receptor Protein Using a Homologous Recombination Vector Construct

A constitutive or inducible promoter and selectable marker are inserted by homologous recombination into a human cell line that contains an endogenous copy of CNTFR, and cells are selected for expression of CNTFR according to the above example.

An assay is then conducted using various candidate modulator molecules, by measuring the phosphorylation state of the STAT3 protein. Cloned recombinant cells were grown to subconfluency. Cells were then serum starved overnight prior to ligand treatment. After serum

starvation cells were treated with 100 ng/ml CNTF ligand for 15 minutes. Cells were lysed and levels of STAT3 and phosphorylated STAT3 were measured by Western blot (Fig. 11). Anti-STAT3 and anti-phosphorylated STAT3 were purchased from Cell Signaling (Beverly, MA). By comparison of the phosphorylation levels of the STAT3 protein in cells treated with candidate modulator molecules with levels in cells treated with ciliary neurotrophic factor or solvent controls, one can identify substances that activate the CNTFR. By conducting the same assay in the presence of ciliary neurotrophic factor plus candidate modulator agents, one can detect substances that inhibit the CNTFR.

WHAT IS CLAIMED IS:

1. A method for identifying compounds that modulate a target protein, comprising:

providing cells transfected in such a way as to provide a polynucleotide sequence encoding said target under control of a heterologous inducible promoter;

inducing the promoter under conditions that provide a detectable change in a measurable parameter associated with the cells;

contacting at least a portion of the cells with a test compound to ascertain whether the test compound affects a change in the measurable parameter; and

repeating the contacting step with at least one other test compound.

2. The method of Claim 1, wherein the measurable parameter is a parameter other than growth or survival.

3. The method of Claim 1, wherein the contacting step comprises contacting cells with said test compound while the promoter is induced.

4. The method of Claim 1, further comprising comparing the value of the measurable parameter in uninduced cells with the value of the parameter in induced cells.

5. The method of Claim 4, wherein the measurable parameter has been selected from among a plurality of candidate parameters based on said comparison.

6. The method of Claim 1, wherein the promoter is induced to a degree that provides a detectable change in the parameter but not to a degree that kills the cell.

7. The method of Claim 1, wherein the promoter is induced by contacting the cell with an inducer molecule.

8. The method of Claim 1, wherein the promoter is induced by removal or inhibition of a repressor.

9. The method of Claim 1, wherein the target protein affects ion channel activity of the cell.

10. The method of Claim 9, wherein the target protein is an ion channel protein.

11. The method of Claim 9, further comprising:

identifying at least one test compound that modulates the measurable parameter in the cell;

providing a second cell line that differs from the first cell line in that the inducible promoter controls expression of a reporter instead of polynucleotide encoding target;

contacting the second cell line with the identified test compound; and

ascertaining whether the identified test compound affects the expression of the reporter.

12. The method of Claim 1, wherein said polynucleotide encoding target and said promoter have been transfected into a mammalian cell.

13. The method of Claim 1, wherein said inducible promoter replaces an endogenous promoter and controls the expression of an endogenous polynucleotide encoding target.

14. A method for identifying an ion channel modulator molecule comprising the steps of:

a. obtaining a cell that conditionally expresses an ion channel target;

b. incubating a potential ion channel modulator molecule with said cell; and

c. determining whether ion flow through said ion channel targets has modulated, thereby identifying molecules that modulate said ion channel target.

15. A method according to claim 14 wherein said cell that conditionally expresses said ion channel target has been induced to express said ion channel target.

16. A method according to claim 14 wherein said cell is selected from the group consisting of CHO, CHO-K1, HEK293, COS, Vero, SH-SY5Y, RBL and U20S.

17. A method according to claim 14 wherein the step of obtaining a cell that conditionally expresses an ion channel target comprises genetically adapting said cell to produce an ion channel target.

18. A method according to claim 17 wherein said cell is genetically adapted by transducing or transfecting said cell with an inducible vector comprising an ion channel target.

19. A method according to Claim 18 wherein said inducible vector comprises an inducible cassette wherein said inducible cassette comprises an inducible promoter, an ion channel gene, and a gene conferring resistance to a selection agent for selecting transfected cells wherein said inducible promoter is operably linked to said ion channel gene.

20. A method according to claim 19 wherein said inducible promoter is selected from the group consisting of the heat shock inducible promoter, metallothionin promoter, ecdysone-inducible promoter, FKBP dimerization inducible promoter, Gal4-estrogen receptor fusion protein regulated promoter, lac repressor, steroid inducible promoter, streptogramin responsive promoters and tetracycline regulated promoters.

21. A method according to claim 18 wherein said inducible vector may be activated to express said ion channel target and inactivated to prevent expression of said ion channel target.

22. A method according to claim 14 wherein said ion channel target is an ion channel selected from the group consisting of a sodium ion channel, an epithelial sodium channel, a chloride ion channel, a voltage-gated chloride ion channel, a potassium ion channel, a voltage-gated potassium ion channel, a calcium-activated potassium channel, an inwardly rectifying potassium channel, a calcium ion channel, a voltage-gated calcium ion channel, a ligand-gated calcium ion channel, a cylic-nucleotide gated ion channel, a hyperpolarization-activated cyclic-nucleotide gated channel, a water channel, a gap junction channel, a viral ion channel, an ATP-gated ion channel and a calcium permeable beta-amyloid peptide channel.

23. A method for identifying an ion channel modulator molecule, comprising the steps of:

a. obtaining a cell that conditionally expresses an ion channel target;

b. adding an inducer molecule that induces expression of said ion channel target in said cell;

c. measuring membrane potential of said cell;

d. incubating a potential ion channel modulator molecule with said cell;

e. measuring changes in membrane potential; and

f. determining whether ion flow through said ion channel targets has been modulated, thereby identifying a molecule that modulates said ion channel.

24. A method for screening chemical compounds to identify an ion channel modulator compound, comprising the steps of:

a. obtaining a cell that conditionally expresses an ion channel target;

b. adding an inducer molecule that induces expression of said ion channel target in said cell;

c. measuring membrane potential of said cell;

d. incubating said chemical compounds with said cell; and measuring changes in membrane potential;

e. determining whether ion flow through said ion channel targets has been modulated, thereby identifying compounds that modulate said ion channel target.

25. A method for identifying a membrane receptor modulator molecule comprising:

a. obtaining a cell that conditionally expresses a target membrane receptor;

b. inducing expression of said target membrane receptor;

c. measuring a physiological condition of said cell to obtain a first set of data;

d. incubating a potential membrane receptor modulator molecule with said cell;

e. measuring said physiological condition of said cell to obtain a second set of data; and

f. comparing said first set of data with said second set of data to determine whether said physiological condition of said cell has been modulated, thereby identifying a molecule that modulates said target membrane receptor.

26. A method according to claim 25 wherein the step of obtaining a cell that conditionally expresses said membrane receptor comprises:

a. obtaining a cell that contains an endogenous target membrane receptor sequence and an endogenous noncoding sequence; and

b. inserting an inducible cassette comprising a 5' insertion adapter, a regulatory sequence and a 3' insertion adapter within said endogenous noncoding sequence such that said regulatory sequence is operably linked such that it is able to modulate transcription of said target membrane receptor by the presence or absence of a regulator.

27. A method according to claim 26 wherein said regulatory sequence is a non-mammalian enhancer sequence or a repressor sequence.

28. A method according to claim 27 wherein said non-mammalian enhancer sequence is a herpes virus enhancer or an artificial enhancer.

29. A method according to claim 28 wherein said non-mammalian enhancer sequence is an inducible promoter.

30. A method according to claim 29 wherein said inducible promoter is a herpes virus promoter.

31. A method according to claim 29 wherein said inducible cassette further comprises a target sequence such that said target sequence is transcribed upon induction of said inducible cassette.

32. A method according to claim 31 wherein said target sequence is selected from the group consisting of a G-protein coupled receptor target sequence, a nuclear hormone receptor target sequence, a cytokine receptor target sequence, a protein kinase-coupled receptor target sequence a nicotinic acetylcholine receptor target sequence, a ionotropic glutamate receptor target sequence, a glycine receptor target sequence, a gamma-aminobutyric acid receptor target sequence, and a vanilloid receptor target sequence.

33. A method according to claim 32 wherein said target sequence is 5HT4.

34. A method according to claim 27 wherein said repressor sequence is able to bind a zinc finger protein.

35. A method according to claim 34 wherein said zinc finger protein comprises a KRAB domain.

36. A method according to claim 26 wherein said regulator is VP16 or a functional domain of VP16.

37. A method according to Claim 25 further comprising transfecting said cell with a regulatory expression vector construct comprising a second inducible promoter and a regulator gene encoding said regulator operably linked such that induction of said second inducible promoter by an exogenous stimulus initiates transcription of said regulator gene.

38. A method according to claim 37 wherein said second inducible promoter is a tetracycline inducible promoter or an ecdysone-inducible promoter.

39. A method according to claim 37 wherein said exogenous stimulus is tetracycline, ponasterone, dexamethasone, a heavy metal ion or heat.

40. A method according to claim 25 wherein said step of inducing expression of said target membrane receptor is initiated by the presence or absence or a regulator or by the presence or absence of an inducer.

41. A method for screening a chemical compound library to identify a G-protein coupled receptor modulator molecule, comprising:

a. obtaining a cell that conditionally expresses a G-protein coupled receptor;

b. inducing expression of said G-protein coupled receptor;

c. measuring a physiological parameter associated with said G-protein coupled receptor to obtain a first set of data;

d. incubating a potential modulator of said G-protein coupled receptor with said cell;

e. measuring said physiological parameter to obtain a second set of data; and

f. comparing said first set of data with said second set of data to determine whether said physiological parameter has been modulated, thereby identifying a chemical compound that modulates a G-protein coupled receptor.

42. A method according to Claim 41 wherein said physiological parameter is selected from the group consisting of a cAMP level, a calcium level, and a membrane potential of said cell.

43. An inducible vector containing an ion channel target having a nucleotide sequence shown in SEQ. ID NO.: 1.

44. An inducible expression vector comprising a tetracycline inducible promoter, a pcDNA4/TO vector construct and a human HERG potassium channel gene.

45. An inducible regulatory expression vector construct comprising a subcloning vector, a second inducible promoter and a regulator gene.

46. A cell transduced or transfected with the inducible vector of claim 44.

47. A cell transduced or transfected with the inducible vector according to claim 46 wherein said cell is a CHO cell and wherein said transduced or transfected cell expresses Tet repressor and HERG potassium ion channel gene.

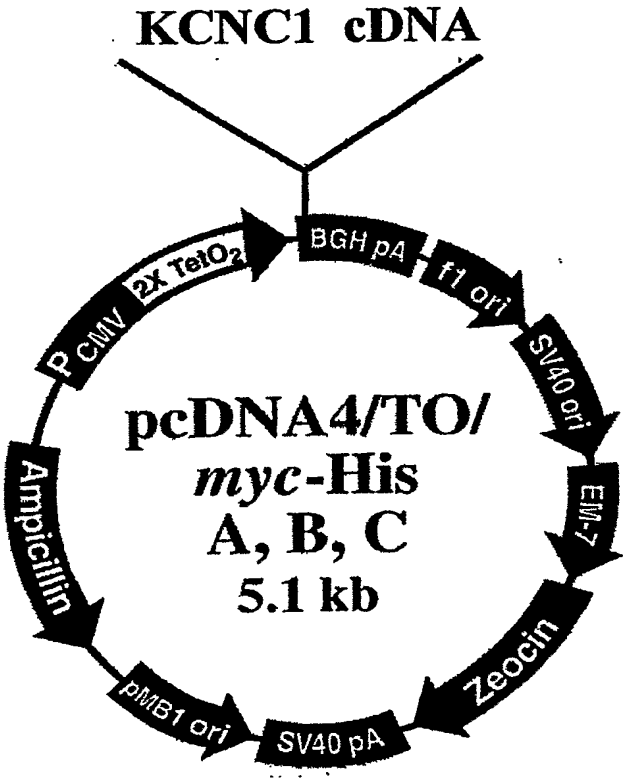
48. An ion channel modulator molecule identified by the method according to claim 14.

49. A membrane receptor modulator molecule identified by the method according to claim 25.

50. A G-protein coupled receptor modulator molecule identified by the method according to claim 41.

51. A kit comprising cells that conditionally express an ion channel target, a compound that induces expression of the ion channel target, and an indicator compound or system for indicating ion channel activity of said cells.

52. A kit comprising cells that conditionally express an ion channel target and a fluorescent dye.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A, B, C
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FIG. 1

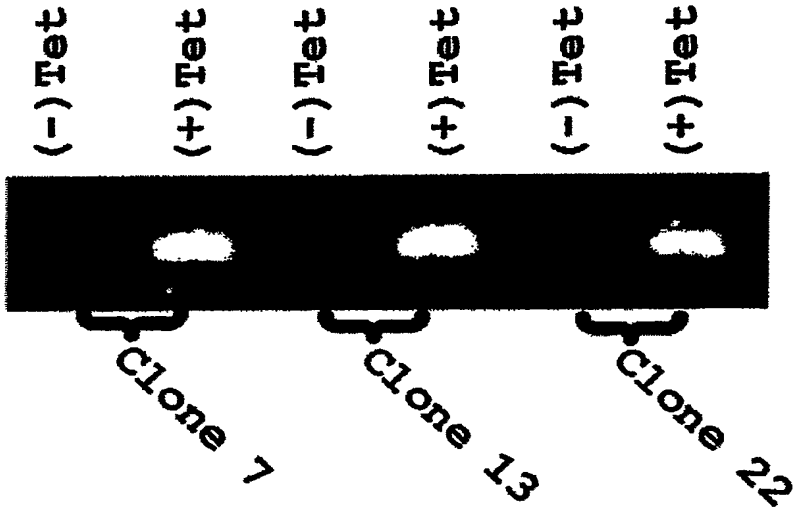


FIG. 2

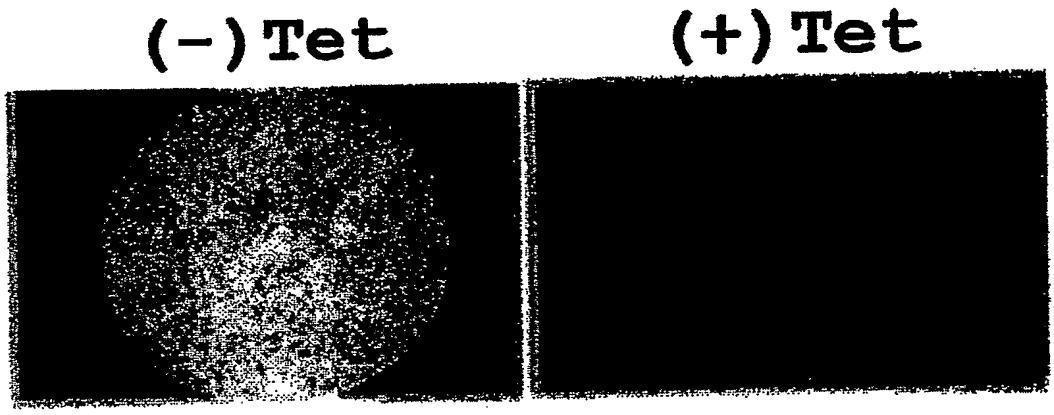
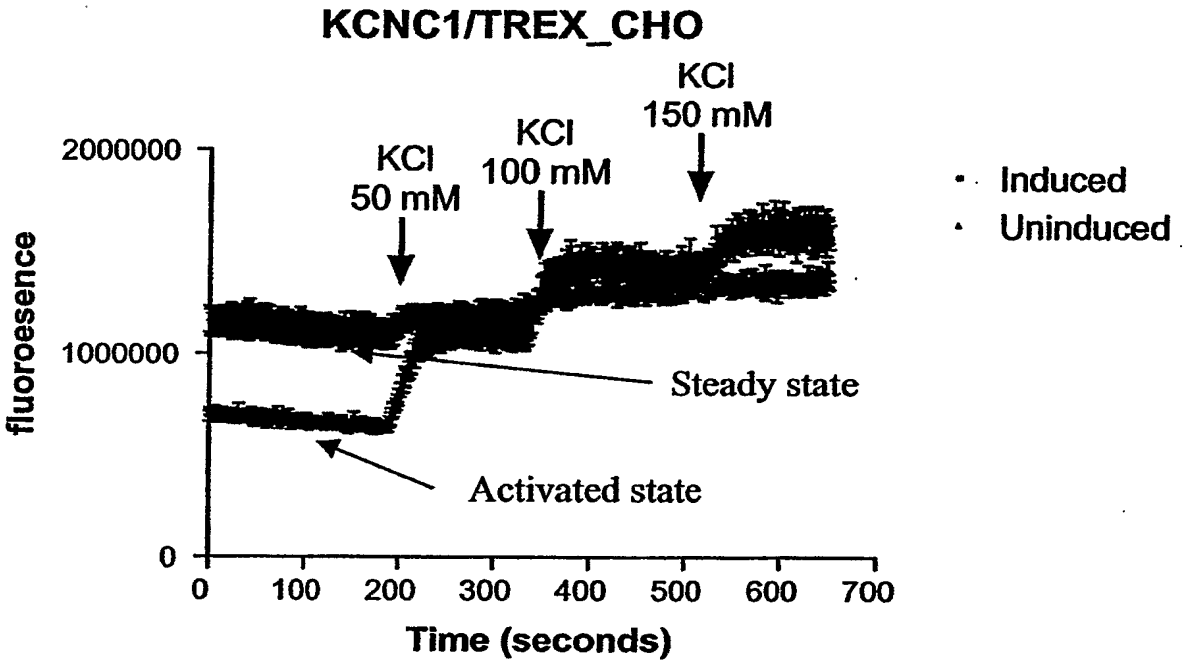


FIG. 3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KCl
100 mM
KCl
50 mM
2000000
1000000
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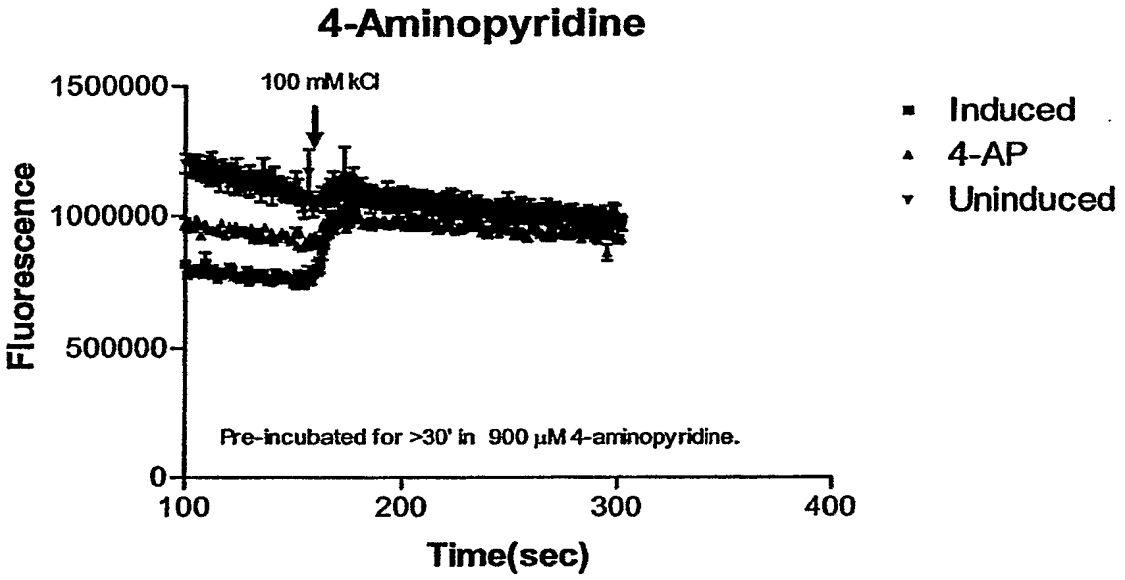
fluoroesence
Induced
Uninduced
Steady state
Activated state
0
100
200
300
400
500
600
700
Time (seconds)

FIG. 4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500000
0
Fluorescence
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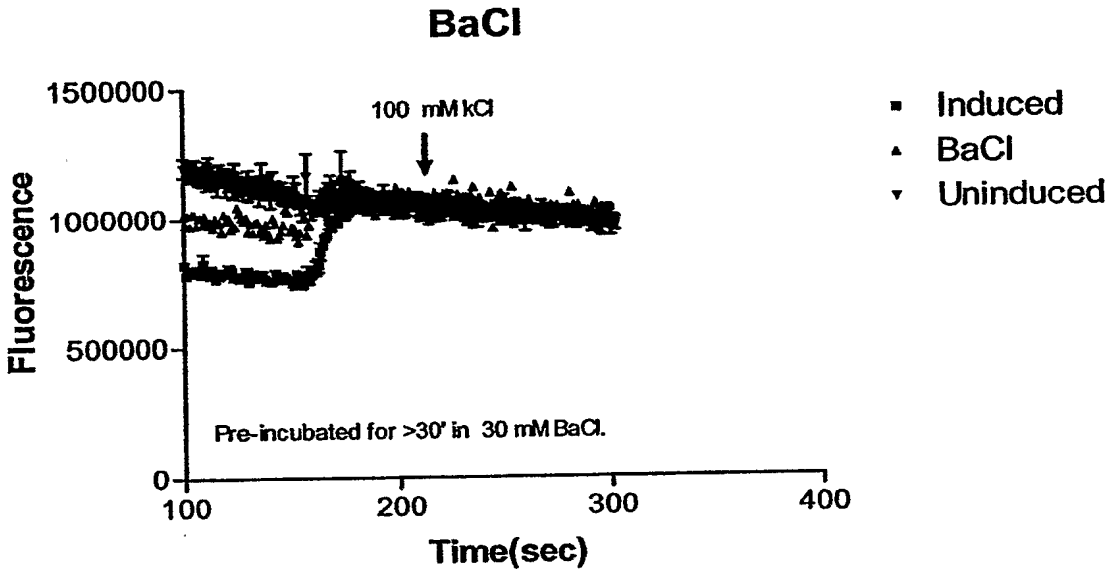
200
300
400
Time(sec)
Induced
4-AP
Uninduced

FIG. 5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1000000
500000
0
Fluorescence
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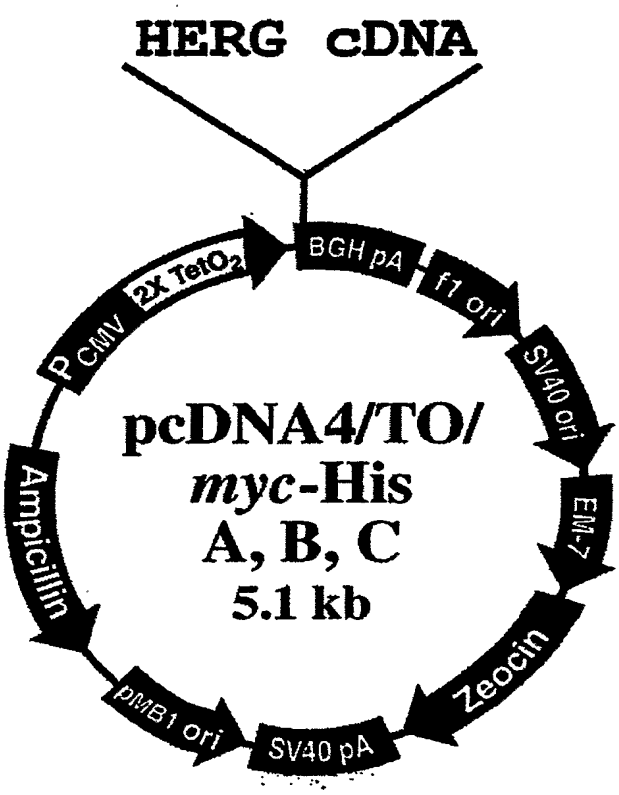
100
200
300
400
Time(sec)
Induced
BaCl
Uninduced

FIG. 6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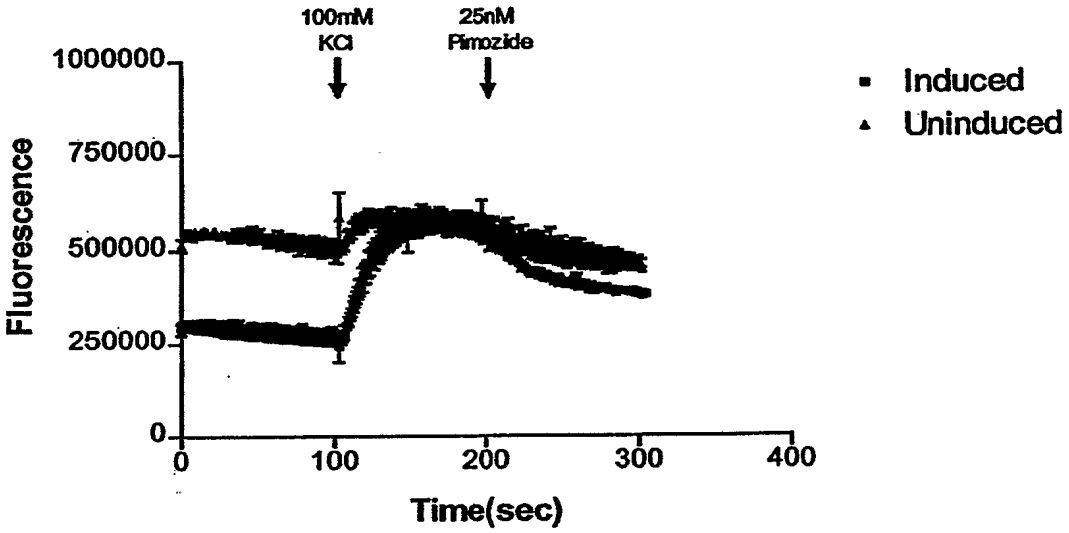
A, B, C
5.1 kb

FIG. 7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Fluorescence
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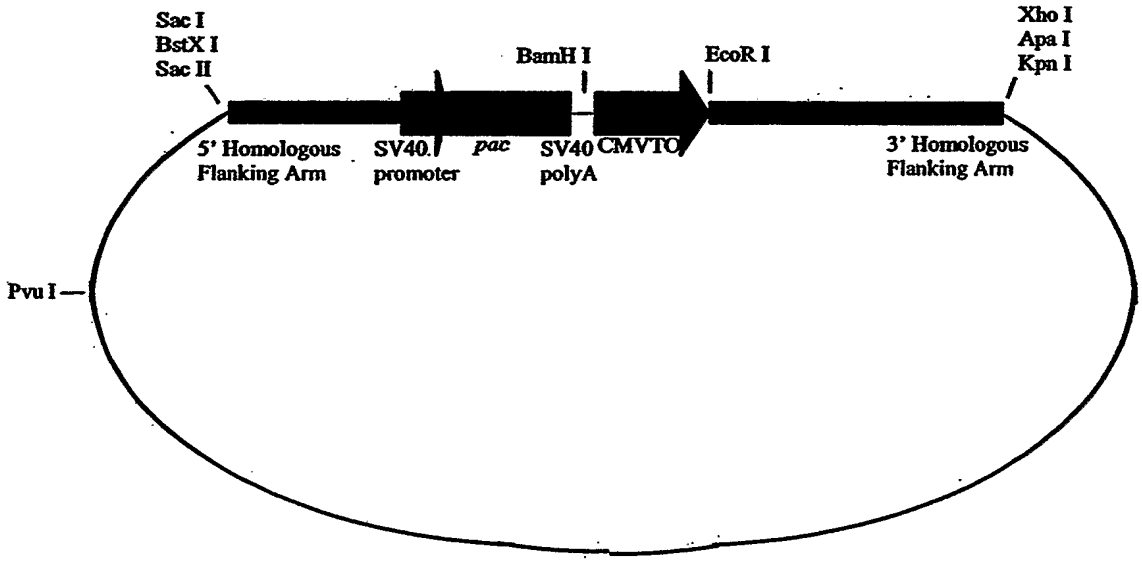
100
200
300
400
Time(sec)
Induced
Uninduced

FIG. 8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BstX I
Sac II
BamH I
EcoR I
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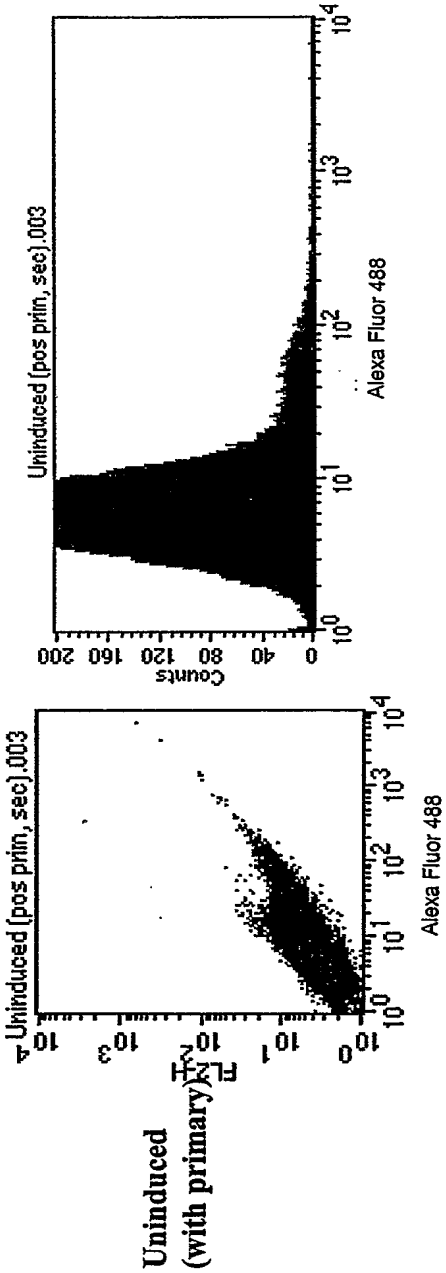
SV40 promoter
pac
SV40 polyA
CMVTO
3' Homologous Flanking Arm
Pvu I

Fig. 9.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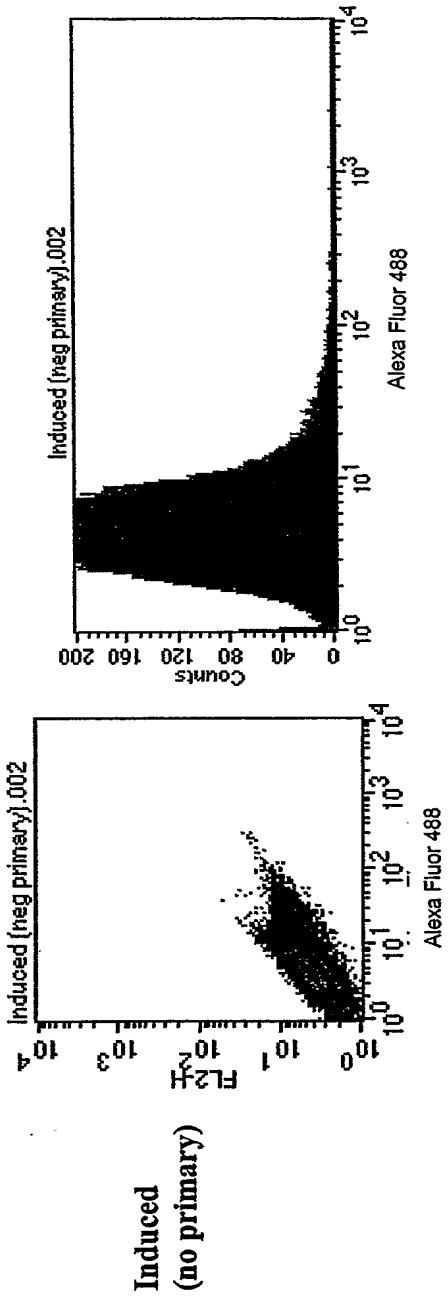
Uninduced (pos prim, sec).003
Counts
Alexa Fluor 488

Fig. 10A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Counts
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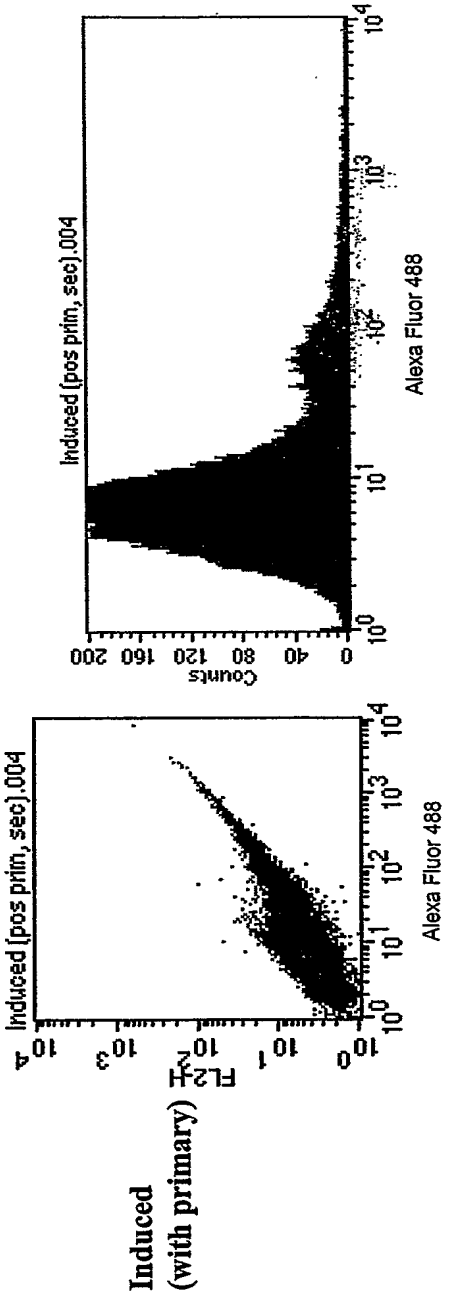
FL2-H
Induced (neg primary).002
Alexa Fluor 488

Fig. 10B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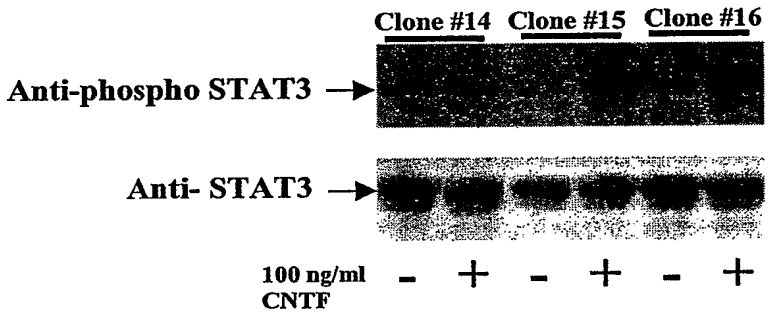
Induced (pos prim, sec).004
Counts
Alexa Fluor 488

Fig. 10C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Clone #16
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Anti- STAT3
100 ng/ml CNTF
- + - + - +

Fig. 11

SEQUENCE LISTING

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BROWN, Steven, J.
DUNNINGTON, Damien, J.
CLARK, Imran

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USING INDUCIBLE PROMOTERS

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